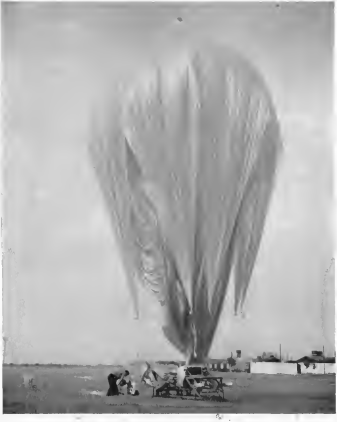

PLATE 1. Balloon used by the Physics Department, Bristol University, for high altitude unmanned flights for studying cosmic radiation. The balloons are manufactured from polythene, ·0015 inches thick, and are approximately 200 feet long and 180 feet in diameter; they are pear-shaped when fully expanded. About 1 per cent of the volume is filled with hydrogen to provide the necessary lift for launching. A balloon of these dimensions weighs about 200 lb and will carry a load of 300 lb to a height of about 100 000 feet.

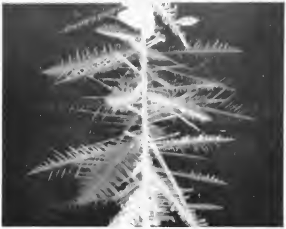

PLATE 2. Branching (dendritic) snow crystals grown on a fibre suspended in a diffusion cloud chamber at Imperial College, London.

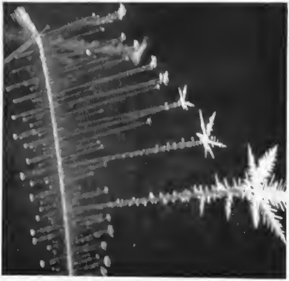

PLATE 3. Needle-like ice crystals grown on a fine fibre at –5°C in a diffusion cloud chamber at Imperial College, London. The fibre was then lowered into a region where the temperature was about –12°C. The crystals stopped as needles and star-shaped dendrites grew on their ends.

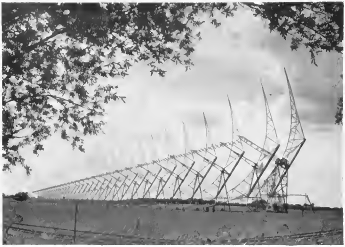

PLATE 4. The fixed aerial of the large radio-telescope at the Mullard Observatory, Cambridge. The aerial extends 1450 feet from east to west. By using it in conjunction with a movable aerial which runs on a 1000-foot railway track running from north to south, observations can be combined to give a resolving power equivalent to two aerials each of area 8 acres arranged as an interferometer.

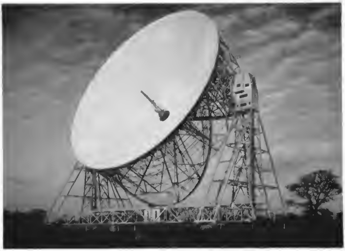

PLATE 5. The 250-ft fully-steerable radio telescope at the Nuffield Radio Astronomy Laboratories, Jodrell Bank, Manchester University.

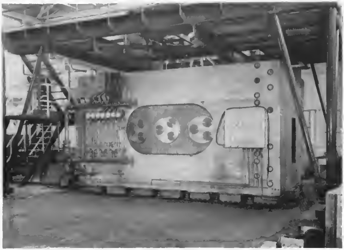

PLATE 6. General view of the 300-ton magnet surrounding the vacuum tank of the British hydrogen bubble chamber at the Rutherford High Energy Laboratory, Harwell, for use with the C.E.R.N. 25 GeV proton synchrotron and the N.I.R.N.S. 7 GeV proton synchrotron. The nine windows (blanked off by metal) for illuminating the chamber can be seen as well as the four main expansion pipes at the top of the magnet.

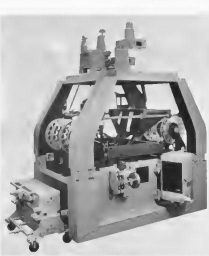

PLATE 7. Automatic co-ordinate measuring machine designed by a group at Imperial College, London, for recording particle tracks in photographic plates which have been exposed to bubble chamber tracks or to cosmic radiation in balloon flights. The recorded tracks are used to determine the different kinds of particles, their energies, the length of their lives and the kinds of other fundamental particles into which they decay. The film spools can be seen on either side of the machine.

PLATE 8. A photograph taken at the Marine Biology Station, Menai Bridge, Anglesey, showing a slate slab treated with barnacle extract on the left-hand side but left untreated on the right-hand side. Notice the simulation of the gregarious behaviour of the barnacle spat caused by the treatment.

PLATE 9. Polyethylene single crystals photographed at the Physics Department, Bristol University, showing internal structure revealed by diffraction effects. Magnification ×2500.

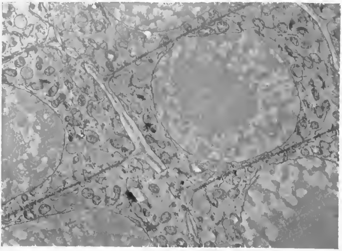

PLATE 10. Electron photomicrograph taken at the Botany Department, Oxford University of cells with "resting" nuclei in very early stage of division (mitosis) showing early breakdown of membrane of the cell nucleus. Longitudinal section of barley root tip. Magnification ×1850.

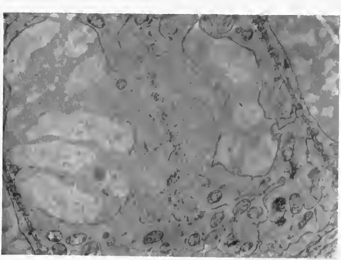

PLATE 11. Electron photomicrograph taken at the Botany Department, Oxford University of a later stage in cell division (mitosis) with daughter nuclei already separated and formation of bubbles along the equator of the spindle indicating where a new cell wall will form. The lighter areas within the reforming nuclear membranes are chromosomal masses. Longitudinal section of barley root tip. Magnification ×6250.

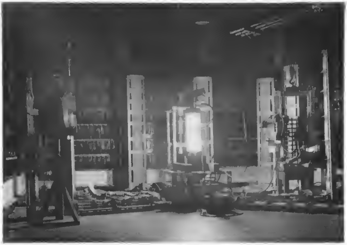

PLATE 12. The large Condenser Bank at Imperial College. A photograph taken by the pulse of light from the high current discharge. The condensers are stacked in ten layers along three sides of a square with their terminals inwards and connected by horizontal strip leads. The discharge tube, about 5 ft high, is in the centre of the square.

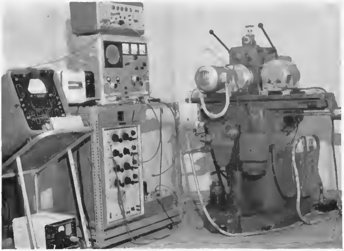

PLATE 13. Determining the torsional characteristics of a milling machine spindle drive in the Department of Mechanical Engineering, Birmingham University. The torsional vibration is excited by a novel centrifugal device developed by the Engineering Department.

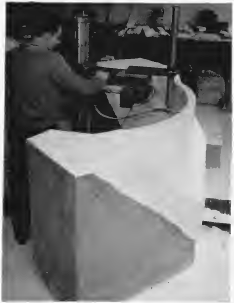

PLATE 14. Plaster of Paris model of a constant-thickness arch dam made in the Department of Civil Engineering, Southampton University, for a stress analysis of this type of dam. The photograph shows the model being trimmed to shape.

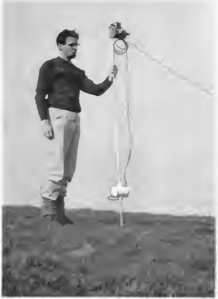

PLATE 15. Differential proton magnetometer developed by the Research Laboratory for Archaeology and the History of Art, Oxford. The two detector bottles are carried at either end of a five-foot dural rod.

Chapter 1

Introduction and Summary

1. This report, which is the first of its kind, describes one of the chief activities of the Department of Scientific and Industrial Research—the encouragement of research and postgraduate training mainly in universities and colleges. It covers the period from the passing of the D.S.I.R. Act in August 1956 to December 1960. An outline of the functions and organization of D.S.I.R. is desirable as a background to this report, and this is given in the following paragraphs which precede the general account of grants and awards.

ACTIVITIES OF D.S.I.R.

2. The Department of Scientific and Industrial Research was founded in 1916 to promote and organize scientific research with a view especially to its application to industry and trade. Although World War I prompted this action by the Government, experience in peace time has shown the wisdom of the decision. Particularly since World War II the same national need for such research has become even more pressing and widely appreciated. How the activity of D.S.I.R. has grown over the same period is illustrated by the following figures for annual expenditure at 5-year intervals. Even allowing for the change in the value of money, it is clear that there has been considerable expansion:

1919–20	£0·33m	1934–35	£0·55m	1949–50	£3·91m
1924–25	£0·54m	1939–40	£0·65m	1955–56	£6·53m
1929–30	£0·54m	1944–45	£0·91m	1959–60	£10·3m

3. The activities of D.S.I.R. cover all the main branches of the natural sciences and their application in technology outside the fields of defence, nuclear energy, medicine and agriculture. Further, in recent years aspects of such human sciences as psychology and sociology have been included that are related to industrial needs, and so have studies in economics which enable D.S.I.R. to assess the economic value of its activities to the community and the research needs of industry.

4. Within this wide range of science and technology, the activities of D.S.I.R. can be grouped under three broad headings:

(i) Research in the national interest and to meet the needs of Government departments.

(ii) The encouragement of industrial research and the application of scientific knowledge in industry.

(iii) The encouragement of scientific and technological research mainly in universities and colleges; and assistance in maintaining an adequate supply of trained research workers and of certain other scientists and technologists with postgraduate training.

5. The first of these three functions is discharged through the work of fifteen national laboratories and research stations under the direct control of D.S.I.R.

6. The second, the encouragement of industrial research, is effected mainly through industrial research associations. These have been set up on a

co-operative basis in order to serve the needs of particular industries. They are financed largely by firms in the industries themselves but are assisted by grants from D.S.I.R. There are now over fifty such associations covering most of the important branches of British industry.

7. The third chief function of D.S.I.R., namely the encouragement of research and postgraduate training mainly in universities and colleges, is effected through research grants, studentships and fellowships. These are the subject of this report.

8. The Lord President of the Council and Minister for Science is the Minister responsible for the Department of Scientific and Industrial Research. Under the D.S.I.R. Act of 1956 executive control of the Department was vested in a Research Council, called the Council for Scientific and Industrial Research, replacing the Advisory Council which came into existence the year before the formation of D.S.I.R. in 1916. The membership of the Research Council during the period under review is given in Appendix B 2 (i). The members are drawn from industry, the trade unions and the universities. The chairman during the period under review was Sir Harry Jephcott. The Secretary, Sir Harry Melville, K.C.B., F.R.S., is the Permanent Secretary to D.S.I.R.*

9. The Research Council has set up a number of Committees of Council (many of whose members are not members of the parent Council) to advise it and the officers of the Department on the various activities of D.S.I.R. The three committees responsible for activities covered by this report, are the Postgraduate Training Awards Committee (P.T.A.C.), the Research Grants Committee (R.G.C.) and the Human Sciences Committee (H.S.C.). (The members of these three Committees are listed in Appendix B 2.) The secretariat of these committees and the administration of the grants and awards are the responsibility of the Grants Division of D.S.I.R.

FUNDS FOR RESEARCH IN UNIVERSITIES AND COLLEGES

10. The encouragement by D.S.I.R. of research in universities and colleges takes the form of financial support through research grants. In considering first of all the circumstances of British universities (as distinct from colleges of advanced technology and certain other technical colleges for which the Ministry of Education accepts a financial responsibility) it must be borne in mind that the general financial provision from Government sources for teaching and research in British universities is the responsibility of the University Grants Committee (U.G.C.). There is however frequent consultation between the relevant committees of D.S.I.R. and the U.G.C. and each body appoints assessors to the other. Scientific and technological research in the universities is in fact financed from a number of sources, which fall under four main heads:

(i) the general income of the universities themselves, which these days comes largely from Government quinquennial grants made on the recommendation of the U.G.C.;

---

* Further details of the work of D.S.I.R. will be found in its annual reports, in the annual reports of the research stations, and in "Research for Industry" which also appears annually and describes the work of the research associations. All these are published by H.M. Stationery Office.

(ii) grants awarded by the Government's four Research Councils (D.S.I.R., the Agricultural Research Council, the Medical Research Council and the Nature Conservancy) and the Government research grant distributed by the Royal Society mostly to aid projects in which the main initiative has come from university investigators;

(iii) similar grants made by other outside bodies such as private research foundations, industry, and defence and executive departments of government;

(iv) research contracts placed by Government departments (including D.S.I.R.), and by industrial and other organizations, for sponsored projects which they wish to initiate, usually as part of their own programmes of research and very often with a view to using the results themselves.

11. The traditional and successful association of research with teaching has resulted in the encouragement by D.S.I.R. of pure and applied research at universities and more recently at other institutions of higher education such as colleges of advanced technology. An adequate volume of active research in universities and colleges has come to be recognized as an essential part of British academic life and particularly as a safeguard for the economic future of the country. Scientific research, pure or applied, is recognized both for its intrinsic intellectual value and as the foundation of the scientific and technical advances of the future upon which industrial prosperity must rest.

12. But scientific research on its present scale and complexity is costly in men and equipment. Moreover, the cost is variable and difficult to predict. Since its establishment, therefore, D.S.I.R. has been a source of aid for initiating researches of special timeliness and promise and has thus been able to help in fostering new ideas whose development might otherwise have been too great a burden on the resources of universities and colleges. In a comparatively small way D.S.I.R. had carried out this function since its creation, but in the last few years, recognizing the much greater part which science has come to play in the life of the nation and the inadequate use of the scientific potential in the highly qualified and able staff of universities, this help for research in universities has been greatly expanded. As will be seen from the figures elsewhere in this report, considerable sums of Government money are now being provided through D.S.I.R. earmarked for scientific research and postgraduate training. D.S.I.R. has had to work out by experience how to achieve the degree of control which is required by Parliament over this use of public funds, while providing for those using these resources as much freedom for their researches and for training as is consistent with this control. By employing at Headquarters scientists with an understanding of the requirements of research and training, and by securing the help of advisers most of whom are scientists in universities and colleges, D.S.I.R. has evolved procedures which, because of mutual understanding of the problems involved, would seem to be proving satisfactory in practice. Economy and propriety in spending public money has been achieved at the same time as effectiveness in helping research.

13. New problems arise with the increases in the funds provided by the Government for research and in the sums required for the largest individual projects. D.S.I.R. is constantly considering these problems with the aim of modifying its

procedures in such a way as to provide the scientist with the resources he needs, and yet to retain the right amount of financial control without at the same time requiring from him more than is necessary of the scarcest of all his resources—time available for research. Further consideration is given in Chapter 3 to the problems of administering large grants.

14. Since its earliest days, D.S.I.R. has made these grants to help investigators to initiate promising new researches. The grants have been awarded with the expectation that if the work became successfully established, D.S.I.R. would look to the university to accept full administrative and financial responsibility. In this way any risk of D.S.I.R. finding itself in virtual control over a significant part of university research is avoided, and the institution itself is placed in the best position to decide on changes which may be desirable in the light of progress of research initiated with grants. Clearly the most appropriate time for such assimilation by universities is at the beginning of each new university quinquennial grant period. Discussion and agreement between D.S.I.R., the universities and the U.G.C. is designed to make this process of assimilation work smoothly and effectively.

FUNDS FOR POSTGRADUATE TRAINING IN UNIVERSITIES AND COLLEGES

15. Considerations broadly similar to those relating to research grants account for D.S.I.R. providing also for awards for postgraduate training in science and technology. These awards are required to help maintain for the United Kingdom an adequate supply of trained research workers and of certain other scientists and technologists with a postgraduate training who are required on the staffs of universities and colleges and as research workers for government and industry. For its training awards D.S.I.R. seeks to estimate the national need for postgraduate education in various branches of science and technology and to distribute its awards equitably among the different research schools, whether in universities, colleges of advanced technology, other technical colleges or other places of higher education and research. In the allocation of awards between the different research schools, judgements therefore need to be made similar to those in supporting research, since research and training must be closely integrated.

FINANCING D.S.I.R. SUPPORT

16. D.S.I.R. now plans financially for the future of all its activities up to five years ahead. This is particularly necessary in the financing of research where commitments must be made to ensure continuity in the work undertaken. In making its plans D.S.I.R. needs to relate the resources which will be needed for both research and training. The projected increase in student numbers in the universities and in colleges such as those of advanced technology: the increasing proportion of those students reading science and technology: the increasing number of students who continue with study and research training after graduation—all these must be taken into account. In making its plans D.S.I.R. has especially in mind the increased numbers of university and college teachers which will be required, and the growing needs of Government and industry for men and women with advanced training in science and technology.

GROWTH OF D.S.I.R. SUPPORT

17. Before proceeding to the more detailed chapters of the report, a few statistics will illustrate the growth since World War I of Government support for scientific

and technological research and postgraduate training in universities and colleges through the medium of D.S.I.R. research grants and training awards. Table (a) gives figures for six separate financial years, three at five-year intervals before World War II and three at five-year intervals after it. The diagrams that follow illustrate further aspects of this growth.

Table (a)

<table>
<tr><th rowspan="2">Financial Year (Apr/Mar)</th><th colspan="2">Cost in year (£000)</th><th colspan="2">No. current on 1st Oct.</th></tr>
<tr><th>Research Grants</th><th>Training Awards</th><th>Research Grants</th><th>Training Awards</th></tr>
<tr><td>1929–30</td><td colspan="2">37</td><td>39</td><td>155</td></tr>
<tr><td>1934–35</td><td colspan="2">28</td><td>50</td><td>164</td></tr>
<tr><td>1939–40</td><td colspan="2">24</td><td>39</td><td>119</td></tr>
<tr><td>1949–50</td><td>344</td><td>212</td><td>95</td><td>844</td></tr>
<tr><td>1954–55</td><td>315</td><td>323</td><td>53</td><td>1060</td></tr>
<tr><td>1959–60</td><td>916*</td><td>904</td><td>525*</td><td>2464</td></tr>
</table>

* Includes Human Sciences and Space Research.

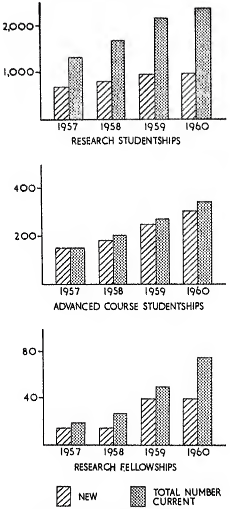

FIG I. *Numbers of new D.S.I.R. Studentships and Fellowships taken up and Numbers Current in October 1957 1960.*

Note. To ensure comparability from year to year the 77 First Year Studentships awarded in 1960 have been shown as 45 Research Studentships and 32 Advanced Course Studentships.

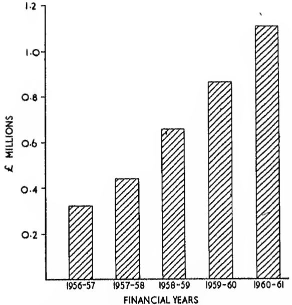

FIG. II. *Expenditure on D.S.I.R. Studentships and Fellowships in the Financial Years 1956–57 to 1960–61*

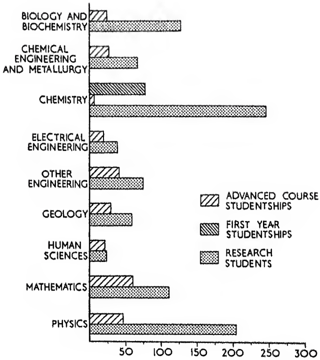

FIG III. *Numbers of New Studentships taken up in each Group of Subjects in 1960.*

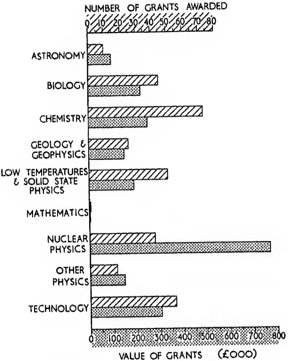

FIG IV. *The Numbers and Values of D.S.I.R. Research Grants awarded in each Group of Subjects during the Year beginning October 1959.*

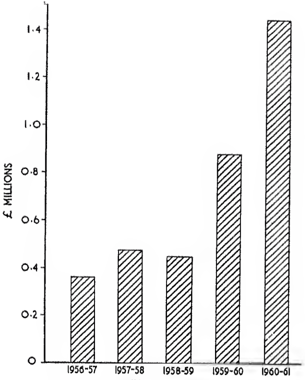

FIG V. *Expenditure on D.S.I.R. Research Grants in the Financial Years 1956–57 to 1960–61.*

Chapter 2

Postgraduate Training Awards Studentships and Fellowships

SECTION I: D.S.I.R. SCHEMES

PURPOSE

1. To maintain an eminent position as an industrial power the United Kingdom depends increasingly on its scientists, engineers, technologists and technicians. In recent years the number and quality of men and women trained in these groups has increased. The special responsibility of D.S.I.R. is to encourage postgraduate training in science and technology and to do so on a scale which matches the current expansion of universities and colleges.

RESEARCH STUDENTSHIPS

2. D.S.I.R. encourages the training of research workers largely through its Research Studentships, which are awarded to young honours graduates in science and technology to support them while they receive up to three years of full-time training in the methods of research. This usually takes that form of "apprenticeship" in research which in universities leads to the Ph.D. degree. This scheme of awards started in a small way during World War I and has now grown quite large: in the autumn of 1960, 942 Research Studentships were awarded, raising the total number then current (including second and third-year renewals) to 2377.

RESEARCH FELLOWSHIPS

3. The Department's scheme for postdoctoral Research Fellowships supplements that for Research Studentships. These senior awards are much fewer, and 75 were current in the autumn of 1960. They are intended for promising young research workers who have completed the normal course of postgraduate training and shown such a marked aptitude for original and independent research that they merit full-time opportunity to develop it further.

ADVANCED COURSE STUDENTSHIPS

4. In 1957 D.S.I.R. introduced its Advanced Course Studentships for young honours graduates in science and technology attending full-time postgraduate courses of instruction, which lead, usually in one year, to such qualifications as an M.Sc. degree or postgraduate diploma. In 1960, 274 of these awards were made.

GROWTH OF D.S.I.R. RESPONSIBILITY

5. Before 1957 there were in England and Wales three main sources of support from public funds for postgraduate students in science and technology. D.S.I.R. awarded Research Studentships, which were fewer in number than now and were called Maintenance Allowances; the Ministry of Education was prepared to extend its undergraduate State Scholarships for postgraduate study, and to supplement approved university and college scholarships to bring them up to

the value of State Scholarships; and a large number of local education authorities made awards for postgraduate study. The disadvantages of these divided responsibilities mattered more as the need grew for more awards. For example, the older universities tended to be better endowed with scholarships than were some of the newer foundations, and so the latter fared less well under a system based on supplementing university and college awards. Again, some local education authorities were less enthusiastic than others about their responsibilities for postgraduate education, and made less generous provision at this level; and, perhaps the most important disadvantage, the divided responsibility made it difficult to take into account the overall national requirements. Therefore it was arranged that, starting in 1957, D.S.I.R. should take over from the Ministry and the local authorities in England and Wales almost the whole of their parts of the previously shared responsibilities for awards from public funds for honours graduates in science and technology. There was no corresponding change in Scotland. (At the same time the Ministry of Education introduced a system of new postgraduate awards, called State Studentships, for graduates in the arts, including law, music, divinity, certain of the social sciences, etc., to relieve the local authorities in England and Wales of certain postgraduate responsibilities in these fields.) The consequence is that in the U.K., D.S.I.R. now supports about 45 per cent of all postgraduate students in science and technology.

6. By serving as a central source of support for a considerable part of the postgraduate training in science and technology, D.S.I.R. is able, with the help of advisers knowledgeable about the needs of the universities and of the nation, to keep in balance the distribution of awards between subjects and between universities. Special help can be given where it is most needed and adjustments made in the allocations to ensure that the awards are most effectively used. In addition, the experience of universities and colleges is available to D.S.I.R. through its advisers, so that changes in the schemes of awards can be made to meet new conditions.

COMMITTEE STRUCTURE

7. The Department's administrative arrangements for these tasks make provision for expert advice from outside. One of the committees of the Council for Scientific and Industrial Research is the Postgraduate Training Awards Committee (P.T.A.C.). This committee consists of a chairman, who is eminent in the academic world and who is also a member of the parent Council, together with one or two other members of the Research Council, and nine scientists and technologists, usually professors, one for each of the nine main subjects or groups of subjects in which D.S.I.R. makes awards. The Council appoints three further members after consultation with the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom; and it appoints also a member especially well acquainted with the needs of the colleges of advanced technology and other technical institutions. The Chairman of the U.G.C. and an Assistant Secretary of the Ministry of Education serve as Assessors representing the interests of the official bodies most closely concerned. (The terms of reference of the P.T.A.C. and a list of its members since 1956 are given in Appendixes B 1 (i) and B 2 (ii) respectively). The secretariat of the Committee is provided by the Training Awards Section of the Grants Division of D.S.I.R., whose officers administer the awards.

8. The P.T.A.C. has nine sub-committees: for biology and biochemistry, chemical engineering and metallurgy, chemistry, electrical engineering, other branches of engineering, geology, human sciences, mathematics and physics. Most of the members are heads of departments of science and technology in universities or colleges, and the chairmen are drawn from the parent committee. These subcommittees make recommendations to the parent committee on allotments of Research and Advanced Course Studentships to research schools and postgraduate courses respectively; they also interview selected candidates for Research Fellowships; and more generally they provide the parent body with such advice as it may require.

NUMBERS OF AWARDS

9. The approximate total number of each kind of award to be made annually, for all subjects combined, is settled in advance in the light of the probable demand and the funds available. One of the most important tasks of the Committee is to advise the Research Council on these plans. Other tasks include determining the distribution of awards by subject and institution, and deciding the conditions on which awards shall be made and held.

10. In planning future annual numbers, sometimes for several years ahead, the Committee must take into account *inter alia* what can be foreseen of the likely output of graduates with good honours degrees in science and technology. In the United Kingdom the postwar expansion of universities affects especially the faculties of science and technology; and at the same time the colleges of advanced technology and other technical institutions with postgraduate interests are also expanding in fields which are the concern of D.S.I.R. Hence the numbers of young honours graduates and their equivalents eligible for D.S.I.R. awards and worthy of support for postgraduate training are increasing annually. Furthermore the Government's plans for continuing this expansion create a need for more young graduates qualified to teach in universities and colleges, and it is desirable that most of those who are to teach to degree level or its equivalent should have received a postgraduate training in some speciality. Moreover there are also industries and Government scientific services which require more recruits who have received research or other advanced training in specialized branches of science and technology. The increases in the number of D.S.I.R. awards to meet these needs are discussed further in Section II of this chapter and appear in the statistics in Appendix C. At present, as a result of these increases, most universities and colleges seem able to provide support for enough of their good students from D.S.I.R. and the other sources available to them.

DISTRIBUTION OF STUDENTSHIPS BETWEEN SUBJECTS

11. The total numbers of new Studentships having been decided for the year, the P.T.A.C. must divide them between the various academic disciplines and, within disciplines, between the various institutions applying to D.S.I.R. for quotas of awards. As a first step, each spring, the P.T.A.C. divides up the bulk of the year's new studentships between its nine sub-committees each specializing in a subject or group of subjects. In so doing the parent committee takes into account the applications for quotas of awards that have been received, the division made in recent years, and a variety of statistical information on such matters as the country's requirements for persons with postgraduate training in different

subjects and the numbers of graduates likely to be wanting postgraduate training in each subject.

STUDENTSHIPS HELD IN RESERVE

12. Although the majority of the new awards for the year are divided in this operation among the subject sub-committees, some are kept back as reserves for two purposes: most of the universities are offered a few awards not earmarked for particular subjects, to enable them to make minor additions to the allocation of awards later in the summer; and a reserve pool of awards is retained by D.S.I.R. to make further adjustments and additions at a still later stage. Institutions find that these awards in their own gift and not earmarked for particular subjects are of help to them, especially for supporting smaller departments.

13. The next step in the annual allocation procedure is for each specialist subject sub-committee to distribute the awards among the various research schools and advanced courses seeking quotas. Sub-committees have before them evidence, statistical and otherwise, to supplement their personal knowledge of individual schools and courses. For example, they take into account the number of D.S.I.R. Studentships taken up by a school or course in recent years, the other postgraduate awards available in that school, the size and quality in the current year of the final honours school (if any) in that department, from which many of the candidates are likely to come, combined with similar evidence for recent years and a written statement supplied in support of the quotas sought. The sub-committees determine the weight which they should attach to different considerations.

THE QUOTA SYSTEM FOR ALLOTTING STUDENTSHIPS

14. Before 1957 the Committee itself attempted to choose between the individuals on behalf of whom applications for Research Studentships were submitted. However, with the growth of the scheme, it was felt that to select candidates centrally at the D.S.I.R. Headquarters, and hence to distinguish between the relative merits of graduates in different subjects at different universities and colleges, was no longer realistic. It seemed better instead to allot most of the awards each year in quotas to the university or college research schools applying. More recently quotas of Advanced Course Studentships have been allotted also to advanced courses (each quota here being for a particular course). It is thus left to the responsible member of the academic staff to nominate to D.S.I.R. for his awards the best students presenting themselves who are eligible on grounds of age, nationality, subject of study, and so forth and who have achieved the necessary qualifying standard of a good honours degree (first or second class honours—an upper second in the case of research students). Not only does this facilitate a balanced distribution between universities but it has the further advantage that the head of the department is not required to recommend an individual to D.S.I.R. several months before degree examinations as used to be the case. Instead, he can wait until the examination results are known and then put his choices to D.S.I.R., knowing that, within his allotment, awards will be available for all those formally eligible.

DIFFERENCES BETWEEN THE TWO SCHEMES OF STUDENTSHIPS

15. Although the D.S.I.R. schemes for Research Studentships and Advanced Course Studentships have much in common, and although the two awards are

of equal annual value and are governed by similar regulations, they serve different purposes. The Advanced Course Studentship was introduced in 1957, to meet a special need, when D.S.I.R. was taking over additional responsibilities from the Ministry of Education and local education authorities in England and Wales. From the outset D.S.I.R. has maintained a list of advanced courses accepted as suitable for the tenure of these awards, and so a decision by D.S.I.R. on the proposed training does not have to be taken for every individual applicant. Acceptance of the course depends upon its falling within the field of D.S.I.R. and whether it appears to be a valuable enough supplement to first degree work, so far as can be judged from the training outline in the curriculum submitted. There is no corresponding formal requirement for Research Studentships because the training project for a Ph.D. degree demands originality and so must differ from one student to another. In the case of the research award the guarantee that the training will be worthwhile depends on the confidence of sub-committee members in the standards of the research schools.

16. The minimum qualification D.S.I.R. demands for a Research Studentship is normally at least an upper second-class honours degree or Dip. Tech. in science or technology, or a qualification accepted by D.S.I.R. as equivalent; for an Advanced Course Studentship, a degree or Dip. Tech. with lower second-class honours is also acceptable. The research award is normally offered initially for two years, and the majority are renewed for a third year; the Advanced Course Studentship is, however, most often awarded for only nine months to a year, and not normally for more than two years.

STUDENTSHIPS HELD ABROAD

17. Although most D.S.I.R. Studentships are held in universities and colleges in the U.K., for many years it has been possible to hold them abroad, subject to the approval of the Committee. Until recently the Committee required to be satisfied that the specialized training offered by the proposed overseas institution was likely to be better than could be found in the U.K. However, in 1958 D.S.I.R. decided more positively to encourage students to hold their awards abroad and to be less strict in the academic justification demanded. The response has been small, but D.S.I.R. has continued, and will continue, to encourage the tenure of its awards outside Great Britain. In 1958, 1959 and 1960 the numbers of newly awarded Studentships held abroad (including those of N.A.T.O. discussed below) were 5, 17 and 11 respectively.

N.A.T.O. SCIENCE STUDENTSHIPS

18. Since 1959 the United Kingdom has been subscribing to a N.A.T.O. fund for Science Studentships and Fellowships. The funds made available to the U.K. have been administered by D.S.I.R. The N.A.T.O. Science Studentships are for purely civil purposes and one of their aims is to encourage postgraduate study abroad. Hence they are similar in purpose to the D.S.I.R. overseas awards. Since 1959, therefore, young British scientists and technologists going abroad have been awarded N.A.T.O. Studentships of equal value to D.S.I.R. awards, though they have at the same time been awarded D.S.I.R. Studentships, in an honorary capacity.

19. Many young graduates are reluctant to go abroad for their research training: some foreign universities have regulations which do not permit a British

undergraduate to prepare from the outset for the Ph.D. degree or its equivalent; further, the student sometimes fears that for the first few months his studies may be hampered by unfamiliarity with the language and that later this may affect his doctoral thesis; in other cases more personal reasons doubtless prevail. Nevertheless, the completion of education in the new surroundings of a foreign country can have value that is often worth the extra effort required on the part of the student. D.S.I.R. looks forward to the continuing growth of the exchange of postgraduate students between the United Kingdom and other countries.

20. As a compromise, some D.S.I.R. and N.A.T.O. students take advantage of the willingness of certain British universities to allow postgraduate students to study abroad for part of the two or three years normally required for the British lower doctorate. Studentship funds received from N.A.T.O. are also used to provide similar awards (again alongside honorary D.S.I.R. Studentships) tenable in the U.K.

21. The D.S.I.R. quota system for Studentships for British universities does not, of course, apply to awards held abroad, and applicants, after they have made tentative arrangements through their British and a foreign professor, must be recommended by name and be interviewed by D.S.I.R. before an award is made. As the objects of these overseas arrangements, besides providing postgraduate training, are to mix promising young British students with those of other countries so as to enable them to benefit from working in laboratories abroad and, more generally, to profit from the interest and stimulus of living and studying in another country, it is desirable to make some common assessment of the applicants for the overseas awards.

D.S.I.R. RESEARCH FELLOWSHIPS

22. The third scheme of D.S.I.R. training awards supplements the Research Studentship scheme. D.S.I.R. Research Fellowships (formerly called Senior Research Awards) are intended for promising young research workers who have completed their normal course of postgraduate training (usually to Ph.D. level). They enable those who have shown a marked aptitude for independent research to devote their whole time to such work. In a sense they are still training awards, and they are normally limited to a tenure of two years. Although it has grown in recent years, the Fellowship scheme remains small (39* new awards and 75* current in October 1960) compared with the Studentship schemes. Fellowships are intended for the outstanding men, since it is desirable that most students should seek salaried appointments after taking their doctorates.

N.A.T.O. SCIENCE FELLOWSHIPS

23. The financial arrangements between the United Kingdom and N.A.T.O. have meant that some of the candidates for D.S.I.R. Research Fellowships have been awarded N.A.T.O. Science Fellowships (purely civil awards like the Studentships) which, for the United Kingdom, are administered by D.S.I.R. In the case of Fellowships, too, award holders going abroad are in addition normally given the corresponding D.S.I.R. award in an honorary capacity. In 1958, 1959 and 1960 the numbers of new D.S.I.R. and N.A.T.O. Fellowships tenable abroad have been 1, 16 and 14 respectively.

---

* Including D.S.I.R./N.A.T.O. Fellowships (see paragraph 23).

YOUNG U.K. SCIENTISTS IN NORTH AMERICA

24. D.S.I.R. Research Fellowships and N.A.T.O. Science Fellowships provide useful temporary appointments to assist the return of able young scientists and technologists who have graduated in the United Kingdom but who have gone subsequently to North America. The opportunities of visiting the U.S.A. and Canada, the high salary figures, the lavish provision of equipment, and so forth, are all attractive to many British graduates whom this country does not wish to lose permanently. Fortunately a proportion of them wish to return home after two or three years if they can find a suitable opportunity to do so. D.S.I.R. therefore makes available its own and N.A.T.O. Science Fellowships to help these graduates to re-establish themselves on their return to the United Kingdom. A number of them have returned home with Fellowships awarded as a result of interviews conducted in North America on behalf of D.S.I.R. by a travelling Board representing mainly certain interests of the Civil Service Commission and the U.K. Atomic Energy Authority.

SECTION II: SOME FACTS AND FIGURES

INTRODUCTION

1. This section describes the growth of the three schemes of D.S.I.R. training awards and gives some information on where the awards are held, who holds them and related matters. It is not possible to give complete sets of strictly comparable figures for D.S.I.R. training awards over the past 40 years or so, as there have been changes during that time in the way the figures have been kept. In particular, although this report covers the period August 1956 to December 1960, in many of the tables no figures appear for 1956 as some of the training awards given by D.S.I.R. from 1957 onwards replaced awards which previously would have been given by the local education authorities or the Ministry of Education.

GROWTH OF THE SCHEMES

2. D.S.I.R. has supported postgraduate students almost from its inception in 1916. Before 1927 it awarded only Research Studentships (formerly known as Maintenance Allowances); Research Fellowships (formerly called Senior Research Awards) began in 1927, and Advanced Course Studentships in 1957. From 1920 to 1940 numbers were comparatively small: in 1920, 132 awards were current, and in 1925, 212; in 1930, 90 Studentships and 5 Fellowships were awarded, and in 1935, 68 and 7 respectively. After 1945 the numbers rose steadily, being 106 and 6 respectively in 1945; 382 and 3 in 1950; and 379 and 5 in 1955. In 1957, when taking over the rest of the responsibilities previously shared in England and Wales with the Ministry of Education and local education authorities, D.S.I.R. might have expected, but for the new arrangements, to award about 400 new Research Studentships, and the Ministry and the local authorities between them about 250. In 1960, 942 Research Studentships, 274 Advanced Course Studentships, 77 First Year Studentships and 39 Fellowships were awarded. The increase in the numbers of Studentships awarded between 1957 and 1960 is shown in Figure 1 on page 6; the increase in D.S.I.R. expenditure on Studentships and Fellowships is shown in Figure II on page 7.

3. In 1957, it seemed likely that the undergraduate intake of university faculties of science and technology would rise by about 5 per cent per year over the next

ten years. Therefore, partly to provide postgraduate awards for the consequent increased output of good honours graduates in the subjects covered by D.S.I.R. and partly to provide the extra university and college teachers of science and technology who would be needed over the years of expansion, D.S.I.R. planned in 1957 to increase the number of new awards by about 10 per cent per annum for five years.

4. For the new award, the Advanced Course Studentship, D.S.I.R. had little experience on which to base its plans, but on the evidence available it was suggested that about 250 should be offered in 1957 (the first year) and that the figure should then rise annually by about 50. Small increases were also planned in the annual numbers of new D.S.I.R. Research Fellowships.

5. Plans were reviewed again in 1958 and these proposals modified. The suggestion then was that the annual numbers of new Studentships and Fellowships and total awards current (i.e. including renewals) should be as shown in Table (a). This table gives also the figures agreed for 1957 and 1958, and the numbers of new awards actually taken up in each year.

Table (a)

Numbers of New Awards Provided for in Plans Drawn Up in 1956 and 1958 and the Numbers Taken Up

Year	Research Studentships		Advanced Course Studentships		Total number of Studentships current† on 1st October		Research Fellowships	
	Planned New awards	Awards taken up	Planned New awards	Awards taken up	Planned	Actual	Planned New awards	Awards taken up
1957	715	649	250	152	1565	1453	8	13
1958	790	777	300	184	2065	1882	17	14
1959	890	926	350	250	2490	2415	22	39
1960	1020	987*	400	306*	2830	2769	27	39

* The 77 "First Year" Studentships awarded under a trial scheme (see paragraphs 16 and 17, Section III) are distributed notionally here as 45 Research Studentships and 32 Advanced Course Studentships.

† The studentships current include, in addition to new studentships, those extended for a second or third year.

6. Later a further increase in the number of university places to a total of 170 000 by the late 1960's or early 1970's was proposed, and so D.S.I.R. reviewed its plans with the following considerations in mind.

7. Firstly, it had to be borne in mind that the larger numbers of undergraduates and comparable students would need more teachers, and that most of the new teachers would need to receive postgraduate training; in fact, for the universities alone, leaving C.A.T.s. and other technical institutions out of the reckoning, it was thought likely that some 6000 more teachers of science and technology

might be needed in the next decade or so. Secondly, the output of undergraduates in science and technology had been increasing at roughly twice the rate formerly expected (5 per cent per annum when plans were being laid in 1956), and the intake of undergraduates into university faculties of science and technology showed that this trend was likely to continue. Thirdly there was some evidence that the proportion of graduates achieving good honours degrees in science and technology was also increasing; hence, if the chances of their receiving D.S.I.R. awards were not to diminish, there would have to be an increase in the number of D.S.I.R. Studentships beyond that warranted by increased intake figures alone. Fourthly, the progress of knowledge in science and technology and the resulting crowded state of undergraduate syllabuses is putting a heavier load on postgraduate training; in fact the unavoidable lengthening of university training in many subjects is likely often to take the form of more postgraduate courses rather than longer undergraduate courses, thus increasing the demand for Advanced Course Studentships.

8. These considerations therefore point to the need to increase further the numbers of D.S.I.R. Studentships offered annually over the next four years.

QUALITY OF GRADUATES AWARDED D.S.I.R. STUDENTSHIPS

9. Tables (b), (c) and (d) show the classes of degree held by students taking up D.S.I.R. Studentships each year. Detailed comparisons from year to year are hampered by changes in the methods of classification of degrees; in more and more degrees where at one time the second class of honours was undivided, it is now divided into an upper second-class and a lower second-class. The most effective indication of the trend of quality over the four years covered by this report is therefore the percentage of Studentships given to graduates with first class honours degrees. In the years 1957, 1958, 1959 and 1960 the percentages

Table (b)

Classes of Degree held by Students taking up D.S.I.R. Research Studentships
1957 *to* 1960

Class of degree	Distribution				Percentage Distribution			
	1957	1958	1959	1960	1957	1958	1959	1960
First-class first degree	253	316	358	353	39·0	40·7	38·6	37·6
Upper second-class first degree	277	334	438	418	42·7	43·0	47·2	44·4
Undivided second-class first degree	100	106	95	118	15·4	13·6	10·2	12·5
Lower second-class first degree*	18	13	6	21	2·8	1·7	0·6	2·2
Higher degree	1	3	7	7	0·2	0·4	0·8	0·7
Other qualifications	-	5	24†	25‡	—	0·6	2·6	2·7
Totals	649	777	928	942	100	100	100	100

* Research Studentships are awarded to holders of degrees with lower second-class honours only in exceptional circumstances.
† includes 2 Diplomas in Technology.
‡ includes 4 Diplomas in Technology.

were, for Research Studentships, 39, 41, 39 and 38, and for Advanced Course Studentships, 13, 13, 8 and 11 respectively. It seems clear from these figures that the considerable expansion in the numbers of D.S.I.R. Studentships has not brought about any significant decline in the proportion of the Studentships going to the most able graduates. The general question of the quality of degree and the kind of alternative qualification that is acceptable for a Studentship is discussed in Chapter 2, Section III, paragraphs 15–18.

Table (c)

Classes of Degree held by Students taking up D.S.I.R. Advanced Course Studentships 1957 *to* 1960

Class of degree	Distribution				Percentage Distribution			
	1957	1958	1959	1960	1957	1958	1959	1960
First-class first degree	20	24	20	30	13·2	13·0	8·0	11·0
Upper second-class first degree	28	48	57	71	18·5	26·0	22·7	25·9
Undivided second-class first degree	65	45	48	57	43·0	24·4	19·2	20·8
Lower second-class first degree	31	61	107	104	20·5	33·3	42·6	38·0
Other qualifications	8	6	19	12*	5·3	3·3	7·6	4·4
Totals	152	184	251	274	100	100	100	100

* includes 2 Diplomas in Technology.

Table (d)

Classes of Degree held by Students taking up D.S.I.R. "First Year" Studentships in Chemistry under Pilot Scheme: 1960 (*see paragraphs* 16–17 *of Section III*)

Class of degree	No.	%
First	24	31·2
Upper second	34	44·2
Lower second	17	22·1
Other qualifications	2	2·6
Totals	77	100

SUPPORT OF POSTGRADUATE STUDENTS IN SCIENCE AND TECHNOLOGY

10. On the forms of application for quotas of awards the universities are invited to give D.S.I.R. information about the other sources of support for postgraduate students. The information covers about 95 per cent of the research students in science and technology in universities and colleges in Great Britain. In 1958, in order to cover the remaining research students in its field, D.S.I.R. obtained similar information from universities and colleges about the departments of science and technology which were not applying for awards. Altogether the

figures obtained covered 5300 research students, of whom 4300 were British residents and the remaining 1000 from overseas. A similar inquiry about Advanced Course Students covered some 820 graduates of whom 280 were from overseas.

11. The main results of this inquiry are shown in Tables (e) and (f) and Appendix C 5, page 179. Table (e) shows how the British research students were supported. The columns headed " all science and engineering" cover all the university and college departments eligible to apply to D.S.I.R. for Studentships. Some of these departments can apply to D.S.I.R. for support for students working in certain fields only, those working in other fields coming within the scope of other research councils or Government departments. The university or college departments in fields where this is possible have been excluded from the column headed "excluding marginal subjects".

Table (e)

The Percentage of British Research Students Obtaining Support from Each Source:
1958

Source	All Science and Engineering		Excluding Marginal Subjects	
	Students in their first year	All students	Students in their first year	All students
University or College ..	13·2	16·1	12·1	15·5
D.S.I.R.	45·1	39·2	47·2	40·7
Other research councils ..	4·5	6·0	1·9	3·1
Ministry of Education or local education authority ..	6·0	6·0	6·2	6·2
Other Government Departments	5·1	5·5	5·5	6·1
Industry	12·9	14·5	15·8	17·5
Charitable trust, learned societies, etc.	4·5	5·2	4·3	5·0
Self-supporting	6·5	5·7	4·3	4·1
Other sources	2·4	1·9	2·5	1·8
TOTALS	100	100	100	100

12. It will be seen in Table (e) that in the second year of the new arrangements for the support of postgraduate students in science and technology, D.S.I.R. was supporting 39 per cent of all British research students working in departments whose subject lay wholly or partly within its province, and 45 per cent of those in their first year. However, in those departments whose fields of study lay wholly within D.S.I.R.'s province 41 per cent of the British research students and 47 per cent of those in their first year were supported by D.S.I.R.

13. Appendix C 5 gives the information collected in this inquiry in greater detail, and shows that the extent to which universities and colleges depend on D.S.I.R. for the support of their research students varies from subject to subject. In most cases the explanation is relatively easy to see. In those subjects which have the most direct application to industry (chemistry and the various branches of engineering) industrial firms support considerable numbers of research

students, who are often working on a problem about which the firm needs an answer. In the biological sciences many research students are supported by the Agricultural Research Council, the Medical Research Council and the Nature Conservancy, and the need for D.S.I.R. Research Studentships is correspondingly reduced. However, in the fields of mathematics and physics the high proportions supported by D.S.I.R. (69 per cent and 54 per cent respectively of British research students) reflect the lack of other sources. They seem to show also that smaller numbers of students in these subjects are supported by college and university awards, and it is difficult to see why this should be so.

14. The information collected about students attending advanced courses is summarised in Table (f). It will be seen that D.S.I.R. supports a smaller proportion of these than of research students. A higher proportion of students support themselves on these relatively short courses than for research training, and more of the students are supported by the local education authorities.

Table (f)

The Percentage of British Advanced Course Students Receiving Support from Each Source; Students in Their First Year Only: 1958/59.

Source of Support	Percentage of Students
University or College	15·3
D.S.I.R.	32·9
Other Research Councils	0·4
Ministry of Education or local education authority	11·6
Other Government Departments	3·3
Industry	18·0
Charitable trusts, learned societies etc.	3·3
Self-supporting	11·6
Other sources	3·5
TOTAL	100

15. D.S.I.R. does not want to trouble universities every year with a special inquiry to cover departments which have not applied for awards, and so the only figures available for the sources of support of research students in 1960 are those obtained from application forms which, as already mentioned, cover some 95 per cent of research students and so are reasonably reliable. When figures for 1959/60 are compared with similar figures for 1958/59 they show a change from the position shown in Table (e) in that D.S.I.R. was, in 1959/60 supporting 45 per cent of British postgraduate research students in science and engineering (including marginal subjects) in their first year alone and in all years taken together.

SUBJECTS IN WHICH AWARDS WERE HELD

16. The numbers of new Research Studentships awarded annually in each group of subjects are shown in Table (g) and the numbers of Advanced Course Studentships in Table (h); the figures for 1960 are also shown in Figure III on page 8.

Table (g)

New D.S.I.R. and N.A.T.O. Research Studentships taken up in Each Group of Subjects 1957–1960

Year Subject	1957		1958		1959		1960	
	Number	Percentage of total	Number	Percentage of total	Number	Percentage of total	Number	Percentage of total
Biology and Biochemistry	85	13·1	94	12·1	106	11·4	125	13·3
Chemical Engineering and Metallurgy..	37	5·7	55	7·1	71	7·7	66	7·0
Chemistry ..	223	34·4	265	34·1	308	33·2	242*	25·7
Electrical Engineering ..	24	3·7	26	3·3	29	3·1	40	4·2
Other Engineering	32	4·9	59	7·6	69	7·4	72	7·6
Geology ..	44	6·8	50	6·4	59	6·4	62	6·6
Human Sciences ..	11	1·7	6	0·8	20	2·2	23	2·4
Mathematics	57	8·8	74	9·5	84	9·1	109	11·6
Physics ..	136	21·0	148	19·0	182	19·6	203	21·5
Total ..	649	100	777	100	928	100	942	100

* In addition 77 "First Year" Studentships were awarded under a trial scheme (see paragraphs 16–17, Section 3, p. 37).

There have been slight fluctuations from year to year in the percentage of awards held in each subject, but no definite trend seems discernable. It should be noted that the figures for 1960 are not entirely comparable with those for earlier years as 77 chemistry students, who in earlier years would have been given Advanced Course Studentships or Research Studentships, were given the new experimental "First Year" Studentships (see page 37) instead.

WHERE THE AWARDS WERE HELD

17. In October 1957 there were 1453 students holding D.S.I.R. Studentships and 18 research fellows holding D.S.I.R. Fellowships; by 1960 the number of current Studentships, at 2769, had almost doubled and the number of D.S.I.R. Research Fellows had increased more than four-fold to 75. Two of the 2769 students in 1960 were studying in N. Ireland and 26 elsewhere overseas; the remaining 2741

awards were held in 59 universities, colleges or other institutions (of higher education except for two) in the U.K. Of these 59 institutions 18 were colleges and schools of the University of London (with 584 D.S.I.R. Students), 11 were colleges of advanced technology, technical colleges and national colleges (with 60 D.S.I.R. Students), 2 were research institutions (2 D.S.I.R. Students) and the remaining 28 were other universities or university colleges (including the College of Science and Technology, Manchester, and the Royal College of Science and Technology, Glasgow) which had between them 2096 D.S.I.R. Students.

Table (h)

New Advanced Course Studentships Taken Up in Each Group of Subjects, 1957–1960.

Year / Subject	1957		1958		1959		1960	
	Number	Percentage of total	Number	Percentage of total	Number	Percentage of total	Number	Percentage of total
Biology and Biochemistry	12	7·9	15	8·2	19	7·6	24	8·8
Chemical engineering and Metallurgy..	28	18·4	31	16·8	38	15·1	27	9·9
Chemistry ..	—	—	6	3·3	10	4·0	4	1·5
Electrical Engineering ..	8	5·3	10	5·4	15	6·0	20	7·3
Other Engineering ..	31	20·4	30	16·3	42	16·7	41	15·0
Geology ..	16	10·5	17	9·2	31	12·4	28	10·2
Human Sciences ..	7	4·6	9	4·9	18	7·2	21	7·7
Mathematics	26	17·1	37	20·1	36	14·3	62	22·6
Physics ..	24	15·8	29	15·8	42	16·7	47	17·2
Total ..	152	100	184	100	251	100	274	100

18. Details of where these Studentships and Fellowships have been held are given in Appendix C 2, page 163, which summarizes the numbers of new and current awards held in each university, college, etc. Fuller details of the numbers of Research Studentships taken up in each subject, at each university, college or other institution each year since 1957 and the number of awards held on each advanced course accepted by D.S.I.R., are available at D.S.I.R. and may be consulted on request.

19. Table (*i*) shows the extent to which the numbers of D.S.I.R. Studentships currently held differ from institution to institution. The institutions with the largest numbers of current Studentships in October, 1960, were Cambridge University (281 Studentships), Imperial College of Science and Technology

Table (i)

The Distribution of the Numbers of D.S.I.R. Studentships Held at Institutions in October 1960

(i) No. of D.S.I.R. Studentships current at each institution	(ii) No. of university institutions at which the numbers of Studentships shown in column (i) were held	(iii) No. of non-university institutions at which the numbers of Studentships shown in column (i) were held	(iv) Total no. of institutions at which the numbers of Studentships shown in column (i) were held
1-10	11	11	22
11-20	7	1	8
21-30	2	1	3
31-40	4		4
41-50	2		2
51-75	7		7
76-100	5		5
101-150	4		4
151-200	1		1
201-250	2		2
251-300	1		1
All institutions	46	13	59

Table (j)

The D.S.I.R. Studentships Held in Each Region of Great Britain: October 1960.

Universities and Colleges in:	New Studentships			Current Studentships		Population of Great Britain (per cent)
	Research Student-ships	Advanced Course Student-ships	First Year Student-ships	Number	Percentage	
London	189	115	55	633	23·1	22·0
Northern England* ..	229	45	55	688	25·1	27·5
Cambridge and Oxford ..	162	31	22	493	36·8	35·0
Remainder of England ..	178	64		517		
Wales	73			173	6·3	5·2
Scotland.. ..	85	19		238	8·7	10·3
TOTAL ..	916	274	77	2742	100	100

* i.e. County Durham, Cumberland, Lancashire, Northumberland, Westmorland and Yorkshire.

(229), Oxford University (212) and Birmingham University (200). These four institutions between them held 922 Studentships, about one third of the total number. As stated above in paragraph 17, in London University as a whole 584 D.S.I.R. Studentships were held, i.e. 21 per cent of all D.S.I.R. Studentships. The numbers of D.S.I.R. Studentships held in different parts of Great Britain is shown in Table (j). It will be seen that the regional distribution of D.S.I.R. awards corresponds fairly closely to the distribution of population.

20. The countries overseas in which D.S.I.R. and N.A.T.O. awards were held between 1958 and 1960 are shown in Table (k). Almost every Western European country had a D.S.I.R. or N.A.T.O. Student or Fellow from Britain working in it during this period; of the European countries France seems to have attracted the largest number, while of all countries the U.S.A. was the one in which the largest number of awards was held.

Table (k)

D.S.I.R. and N.A.T.O. Students and Fellows from the United Kingdom holding their Awards abroad in the Academic years 1958 *to* 1960

Country	1958/59		1959/60		1960/61	
	Students	Fellows	Students	Fellows	Students	Fellows
Austria	1					
Belgium	1					
Canada			3			
Denmark				1	1	2
France		1	2	2	6	2
Germany	2		2	1	1	5
Italy				1		1
Jamaica			1		1	
Netherlands ..					2	1
Norway	2		3		2	
Sweden	1		2		1	3
Switzerland ..	1	1	2	1	2	3
Turkey			1		1	
S. Africa						1
U.S.A.			4	11	9	12
	8	2	20	17	26	30

MOVEMENT OF D.S.I.R. STUDENTS BETWEEN UNIVERSITIES

21. The majority of students taking up D.S.I.R. Studentships continue their studies in the university where they have taken their first degrees. To a certain extent this tendency to remain in the same university may be due to inertia, in that it is generally easier for the student to obtain a place in the university in which he graduated and for the professor or head of department to accept the student of whom he has personal knowledge. On the other hand, the P.T.A.C. believes that it is often in the students' interest to change universities at this stage in their careers and tries to encourage them to do this. (Appendix C 4, page 177, shows details of movement between universities between 1957–60). It

can be seen from Table (l), which shows a steady increase in the proportion of students changing their place of study on taking up a Studentship, that this policy has had a certain amount of success.

Table (l)

Migration of D.S.I.R. Research Students 1957–1960

(For notes on this Table see p. 29.)

	1957	1958	1959	1960	
				Research Students only	Research Students and First Year Students
Students migrating on taking up an award in Britain	85	120	144	174	187
New research studentships tenable in Britain ..	649	772	910	931	1008
Proportion of students migrating on taking up an award in Britain ..	13%	16%	16%	19%	19%
New awards tenable overseas	—	5	17	11	11
Proportion of D.S.I.R. or N.A.T.O. students migrating on taking up awards	13%	16%	17%	20%	19%

MIGRATION BETWEEN UNIVERSITIES

22. It might have been thought that when students change universities on taking up D.S.I.R. awards they would tend to move away from the universities in the less attractive industrial towns to those more attractively situated and especially to the older universities. The details of migration within great Britain given in Appendix C 4, page 177 show, however, that movements of this kind cannot form more than a small proportion of all migration; the answer is a great deal more complicated than this. Hardly any of the major universities and colleges are subject to a one-way movement and virtually all of them receive some D.S.I.R. Students from other institutions and send some of their graduates elsewhere. Oxford and Cambridge draw more students from elsewhere than other universities do—at Cambridge 25 per cent of the students taking up awards in this period were migrants, and at Oxford 23 per cent, compared with an overall average of 16 per cent—but they also send one student elsewhere for every two they receive. Further, as Table (m) shows, of a net immigration of 45 students to Cambridge, 31 can be accounted for by two outstanding research schools.

23. There is a more marked movement away from the colleges of advanced technology and the technical colleges. In the 4 years covered by Table (l), graduates receiving D.S.I.R. Research Studentships were drawn from 23 of these colleges, and Research Studentships were held in 10 of them; whereas they produced 134 holders of D.S.I.R. Research Studentships, 58 awards were

held in these colleges. At only 4 of these colleges was the number of D.S.I.R. Research Studentships taken up more than half as great as the number of D.S.I.R. Research Students produced, and all of them are colleges at which it is possible to study for an internal London Degree. These 4 colleges alone took up 43 of the 58 awards held in colleges of advanced technology and technical colleges. The general question of the holding of D.S.I.R. Studentships in these colleges is discussed in Chapter 2, Section III, paragraphs 21–23, pages 38 and 39.

24. There are very few individual university departments or research schools consistently attracting appreciable numbers of D.S.I.R. Students from other universities. Over 400 research schools apply each year for D.S.I.R. Research Studentships, but only six of them (listed in Table (m)) gained, on an average, at least two D.S.I.R. Research Students a year more than they sent elsewhere during this period.

25. The likelihood that a student will change his university or college on taking up a D.S.I.R. Research Studentship seems to depend to a certain extent on the subject of his research. This is brought out by Table (n) which shows the proportion of D.S.I.R. Research Students specializing in each field who were migrants. It will be seen, for example, that a geologist is almost twice as likely as a chemist to migrate.

Table (m)

University and College Departments having a Net Immigration of Eight or More D.S.I.R. Research Students in the Four Years 1957–60

University College etc.	Department	Emigrants	Immigrants	No. of new D.S.I.R. awards taken up in the Department
Cambridge	Engineering ..	0	16	33
	Organic and Inorganic Chemistry	4	19	68
Liverpool	Physics	0	11	29
Imperial College	Geology	0	9	24
Manchester C.S.T.	Chemistry	0	12	42
Oxford	Organic Chemistry	2	16	42

WOMEN STUDENTS AND FELLOWS

26. Of the 2769 students holding D.S.I.R. Studentships in October 1960, 167 (6 per cent) were women. As about 14 per cent of the 38 000 full-time students studying science or technology in British universities in 1958 were women, it seems clear that a woman graduate in these fields is less than half as likely to proceed to postgraduate training as a man would be. Four of the 75 D.S.I.R. Research Fellows in October 1960 were women.

AGES

27. The ages of the Students and Fellows taking up D.S.I.R. awards in 1960 are shown in Table (o).

Table (n)

Migration Within Great Britain : Analysis By Subject

SUBJECT	1957–1960			
	Emigrants	Immigrants	No. of new Awards	Proportion of immigrants in total no. of new Research Studentships
Biology and Biochemistry	76	78	410	19·0%
Chemical Engineering and Metallurgy	30	34	228	14·9%
Chemistry	135	129	1113	11·6%
Electrical Engineering	14	15	117	12·8%
Other Engineering ..	33	36	233	16·1%
Geology	48	48	211	22·7%
Human Sciences ..	17	16	60	26·7%
Mathematics	58	58	312	18·6%
Physics	123	120	668	18·0%
TOTAL	534	534	3362	15·9%

Notes on Tables (l), (m) and (n):

(a) In these tables an "immigrant" means a student who, having obtained his first degree in another university, has taken up a D.S.I.R. Research Studentship in the given university or department. The same student is called an "emigrant" from the university and department in which he took his first degree.

(b) Not all the students shown as migrants have changed universities in the year shown. For example, a student may have taken his first degree at university X and then gone to university Y where he has done a year's work before receiving his D.S.I.R. award. In these tables he is shown in the columns relating to the year when he was given his D.S.I.R. award and not the year when he left university X for Y.

(c) There are a few other complicated cases (e.g. a student may take his first degree at X and then a postgraduate diploma at Z before going to Y). In such cases, for simplicity, the student is shown as having migrated from the university where he took his first degree to that in which he now holds his Research Studentship, except that where a student has taken two "first" degrees only the second is considered here.

(d) Except in Table (l) the figures exclude students holding awards abroad. Advanced Course Students are excluded throughout, but the figures for 1960 include holders of the experimental "First-Year" Studentships (see page 37).

MARRIED STUDENTS

28. D.S.I.R. is seldom informed when its students marry and so it does not have complete records. When in 1959 information on this matter was needed in order to estimate the cost of proposed changes in the regulations governing students' dependants' allowances a special enquiry was made, and it was found that 171

Table (o)

Ages (completed years of age) on 1st October 1960 *of Students and Research Fellows Commencing D.S.I.R. Awards in* 1960

Age	Students		Fellows	
	Numbers	Percentage of total	Numbers	Percentage of total
19	3	0·2		
20	44	3·4		
21	492	38·1		
22	412	31·9		
23	166	12·8	4	10
24	85	6·5	10	26
25	35	2·7	14	36
26	15	1·2	1	3
27	12	0·9	6	15
28 or more	29	2·2	4	10
Total	1293	100	39	100

out of 1765 male students were married, and 18 of them had children. Table (p) shows the number of students who were married when they took up awards in 1960.

Table (p)

Marital Status of Students whose D.S.I.R. Studentships were first awarded in 1960

	Married	Single	Totals
Males	82	1136	1218
Females	7	68	75
Totals ..	89	1204	1293

EARNINGS OF D.S.I.R. STUDENTS FROM TEACHING, ETC.

29. D.S.I.R. encourages its students to teach or demonstrate mainly to undergraduates, regarding this work as a desirable supplement to their training. Until 1953 half the gross fees for teaching and demonstrating earned by a D.S.I.R. Student was deducted from the value of his award. In 1953 the former Scientific Grants Committee decided that students should be allowed to keep the first £50 of all such fees, and that half the remainder should be deducted, and this change was introduced at the beginning of the academic year. No further substantial change has been made in the relevant regulations since then.

30. As shown in Table (q) there has been a steady rise in the proportion of research students with earnings.

Table (q)

Research Students With Earnings From Teaching or Demonstrating 1952–59

Academic years	1952–53	1954–55	1956–57	1958–9
Total number of students	976	1052	973	1677
Number with earnings	496	656	703	1311
Percentage with earnings	50·8	62·4	72·2	78·2

31. There has also been some rise in the general level of earnings, although this rise has not been by any means steady. This is shown by Table (r) which gives the median earnings of those students who earned something (half the students earn less than the median). This table also shows the quartiles (a quarter of the students earn less than the lower quartile, and threequarters of them earn less than the upper quartile). Table (s) shows the average earnings of students in each year of study.

Table (r)

The Median and Quartile Earnings of those Research Students with Earnings from Teaching or Demonstrating

Academic years	1952–53	1954–55	1956–57	1958–59
	£	£	£	£
Lower Quartile	21·6	27·3	25·1	27·2
Median	33·1	33·5	44·4	43·5
Upper Quartile	51·1	67·4	71·1	62·1

Table (s)

The Average Earnings from Teaching and Demonstrating of D.S.I.R. Research Students in Each Year of Study 1958–59

	Average Earnings Of Those Research Students With Earnings			
	1st Year Students	2nd Year Students	3rd Year Students	All Students
	£	£	£	£
London	74·8	67·8	67·6	70·6
Oxford and Cambridge	61·9	87·4	92·1	77·5
Others	38·5	40·4	36·7	38·9
All Students	50·1	55·5	53·5	52·9

STUDENTS LIVING AT HOME

32. D.S.I.R. Students are allowed to decide for themselves (subject of course to their universities' rules) whether to live at home, in lodgings or in college hall of residence, etc. The proportion of D.S.I.R. Students living at home is small—17 per cent in October 1960. There are, however, as Table (t) shows, appreciable variations from university to university in the percentages of students living at home. One would expect part of this variation to arise simply from the fact that certain universities are almost wholly residential, and from the position of London University in the centre of a large conurbation. However, the large proportion of Scottish students living at home is at first sight more surprising; it is 45 per cent of all D.S.I.R. Students in Scotland and if St. Andrews University, which is almost wholly residential, is excluded, the proportion rises to 50 per cent. This difference possibly arises from the policy of many Scottish local education authorities to encourage their students attending the university nearest their homes.

Table (t)

Place of Residence of D.S.I.R. Students

University, etc.	D.S.I.R. students living		Proportion living at home (per cent)
	At home	In lodgings, college, hall of residence, etc.	
London	129	503	20·4
Oxford and Cambridge	2	488	0·4
Other English Universities and Colleges	176	1027	14·6
Wales	39	135	22·4
Total England and Wales	346	2153	13·8
Scotland	107	132	44·8
Total Great Britain	453	2285	16·5

33. A larger proportion of D.S.I.R. Students than of other students live away from home. The latest available figures published by the U.G.C. (for 1958/59); shows 31 per cent of all students at London University living at home compared with 20 per cent of D.S.I.R. Students in London; and 20 per cent of all students at provincial universities compared with 15 per cent of D.S.I.R. Students in the provinces. Only in Wales is this relationship reversed, with 22 per cent of D.S.I.R. Students, compared with 18 per cent of the students as a whole, living at home.

STUDENTS' CAREERS

34. Table (u) shows the employment taken up by D.S.I.R. Students when their Studentships terminate. It will be seen that the largest group (137, or 29 per cent) took up university posts.

Table (u)

Employment taken up by Research Students whose D.S.I.R. awards terminated in the year ended 30th September, 1959

Public Service	
–Scientific Civil Service	25
–Public corporations and Nationally owned industries	11
Industry	91
University posts	
–Teaching	57
–Research only	79
–Administrative	1
Schools	19
Technical Colleges	18
D.S.I.R. Research Fellowships or N.A.T.O. awards	17
Overseas posts	99
Continuing postgraduate training	17
Miscellaneous	8
No information	25
Total	467

SECTION III: SOME PROBLEMS OF ADMINISTRATION

INTRODUCTION

1. The administration of large national schemes, such as those for D.S.I.R. training awards, is necessarily mainly centralized. The attendant danger is that such schemes will become inflexible, failing to meet the changing needs of those they are intended to benefit. The administrative problems that face D.S.I.R. on Studentships and Fellowships can be grouped in some six main categories—numbers, values, periods of tenure, qualifications, allotment methods and general procedures—and a selection of problems in some of these categories is discussed below.

TOTAL NUMBERS OF STUDENTSHIPS

2. The first recurrent problem, the important one of numbers of awards, has two chief aspects. How many awards should D.S.I.R. make each year, and how should these be divided between subjects ? The first aspect was discussed in Section I of this chapter in connection with the responsibility of the Postgraduate Training Awards Committee (P.T.A.C.) to advise the Research Council on numbers, and again in the part of Section II discussing the growth of the schemes.

3. To sum up these previous discussions, the annual number of awards reflects the national need for science graduates with postgraduate training; the number of students whose future work is likely to benefit from postgraduate training; the number qualified for and desiring such a training; the number on the other hand who on graduation do not immediately enter scientific or technological employment, or teacher training; and the number whose further training the country can afford. Not every graduate who obtains a good honours degree

wants to receive further academic training; and not all graduates entering industry, the civil service, and school teaching require it. As some companies and Government establishments can offer a good research training in their own laboratories directed towards their own needs, they prefer to recruit some or all of their scientific staff immediately after graduation. Scientific manpower being a scarce and expensive resource these counter considerations must be borne in mind alongside the undoubted need, emphasized especially by the universities and colleges, for scientists to study beyond the level of a first degree. Not only must D.S.I.R. when it considers future numbers strive to strike the right balance between these various considerations, but it must decide also both in relation to other probable scientific expenditure by the Government and to Government expenditure as a whole, what constitutes a reasonable annual sum to spend on postgraduate study.

4. Planning the numbers of Studentships which D.S.I.R. should make available for several years ahead is of critical importance, but far from easy. In addition to the factors already mentioned, D.S.I.R. is well aware that it is only one of the sources, albeit the largest one, of support for postgraduate students in science and technology. University funds, private and charitable benefactions and foundations, and help from industry are all sources of support for postgraduate education. It is highly desirable that these other sources of support should exist and continue to grow, and that individuals and organizations should have this way of encouraging what universities and colleges are doing. Furthermore these other studentships and scholarships can be devoted to special needs and purposes and be awarded with a variety in value and conditions which is not possible in a large national scheme. They can provide means of support for the unusual case of the student who is believed by his university to be worthy of support, but, for one reason or another, does not qualify for a D.S.I.R. Studentship. Support from industry is particularly welcome because it indicates that industry shares the Department's interest in the advancement of knowledge which universities are achieving, and also in the higher training and work of able young scientists.

5. In order to judge whether the number of Studentships offered is appropriate to the current circumstances, D.S.I.R. takes into account the demand and the views which are expressed to it formally and informally. Although the initial demand each year is high, D.S.I.R. has learned by experience that there is some duplication between universities in this, as well as a measure of optimism in many departments concerning the achievement of the students about to take their degrees. The willingness of students to remain at a university for postgraduate training is also affected by the value of the Studentships offered and the relationship of this to the starting salaries being offered in employment. In addition it is generally agreed that some measure of competition is desirable for research awards, to ensure that only those who are really qualified by intellectual ability and the necessary enthusiasm are allowed to embark on a training in research at public expense. The balance between all these factors is a complex one, but the figures given in Chapter 2, Section II show that during the last two or three years the high standard of award for D.S.I.R. Studentships has not fallen, despite the substantial increase in the numbers. At the same time there are thought to be few if any, students who in the opinion of their professors are well qualified for postgraduate training, and who wish to undertake it, for whom support is not available from one source or another.

DIVISION OF NUMBERS BETWEEN SUBJECTS

6. The second recurrent problem of numbers of awards is that of allocating to various subjects or groups of subjects each year's new awards. It has already been outlined (in Section I) how each spring the P.T.A.C. sets about doing this in a way that best reflects the national requirements.

7. In this operation certain differences emerge between one subject and another. For example, in chemistry the pattern is for a comparatively large proportion of honours graduate students to seek research training in universities and colleges, whereas in engineering subjects graduates tend to seek employment immediately after graduation. There are several reasons for these differences. In the chemical industry some employers prefer to engage a man already holding the Ph.D. degree; and in this subject there are probably more potential Ph.D. projects to choose from than in some other disciplines. In engineering the present less fashionable status of postgraduate study may derive partly from the regulations of professional institutions, which require a graduate to have experience in practice before he can achieve the normal grade of membership of his institution. Moreover the British engineering industry does not widely accept the need for recruiting men with advanced training in science or technology. In biological subjects the numbers of awards which D.S.I.R. provides are influenced by yet other factors, including the numbers of awards given by other Government bodies such as the Medical Research Council, the Agricultural Research Council, and the Nature Conservancy. It has been suggested that in biology and geology, perhaps more than in other subjects, fluctuations in the numbers of applications may to some extent reflect apprehension over the current employment prospects in different specialities at the time of graduation. Such considerations, which are not always readily susceptible to numerical expression, indicate the kind of considerations which the P.T.A.C. must bear in mind to supplement the available statistics. The numbers of Studentships awarded in each subject in 1960 are shown in Figure III on page 8.

8. Although the Committee constantly watches for fields of research which require special encouragement or which, on the other hand, appear to be getting more than a fair share of the available resources, it feels that the allocation of resources should be in the most general terms. There should be sufficient flexibility to allow for the effect of such influences as tradition and fashion in research; the excitement and attraction of new subjects, such as atomic energy a few years ago and now space research; and above all the attraction of inspiring leaders whose influence can be the most valuable of all these factors.

9. In this matter of numbers of awards, D.S.I.R. has been helped by studies by the Scientific Manpower Committee of the Advisory Council on Scientific Policy of the likely demands for scientists and engineers. For Studentships D.S.I.R. is concerned however with the national demand for postgraduate training and qualifications. Therefore there are limitations to the ways in which D.S.I.R. can use figures which treat graduate scientists and engineers with higher degrees and with only first degrees as uniform groups.

10. It is not easy to find out whether the numbers decided upon have been roughly correct or even to decide what is the ideally correct distribution. The P.T.A.C. is on the look out for signs of surpluses or shortages and welcomes advice, but so far no evidence has come to its attention suggesting that the distribution of awards between disciplines has been demonstrably inappropriate. Nevertheless,

as a more positive check on its practices, the Committee hopes in the near future to conduct a survey of the subsequent careers of those who have held its training awards to see what type of work they are doing after various intervals of time following their postgraduate training. Such a survey will help to assess the impact of the D.S.I.R. Studentship and Fellowship schemes on science and technology in Britain.

VALUES OF AWARDS

11. The second major matter of policy which must be reviewed regularly is that of the values of D.S.I.R. training awards. For many years values have been changed periodically to keep pace with changes in the cost of living, but generally their relative levels have been preserved, However, in 1958 the P.T.A.C. felt the time had come for a more fundamental review of the principles that should determine the values of the awards, and so launched a more basic study. This is reported in Chapter 2, Section IV.

PERIODS OF TENURE

12. The time required to take the Ph.D. degree seems to be lengthening: in the autumn of 1951, 219 out of 339 D.S.I.R. Research Studentships (i.e. 64·6 per cent) were renewed for a third year, whereas in the autumn of 1960, 583 out of 725 (i.e. 80·4 per cent) were renewed. Occasionally the Committee is asked to extend a Research Studentship for a fourth year but it remains convinced that this is too long a period for a student to spend in postgraduate predoctoral training at the public expense save in exceptional cases.

13. The period of tenure of the Advanced Course Studentship is governed by the length of the course being undertaken, and for this award D.S.I.R. is prepared to accept full-time postgraduate courses of between six months and two years.

14. Research Fellowships are offered in the first instance for two years. In exceptional cases, however, the Committee is prepared to renew the award for a third year but considers that normally by the time a young research worker has reached this stage of his career he should be ready to take up an academic or other research appointment.

STANDARDS OF DEGREES

15. The P.T.A.C. has always attached special importance to maintenance of a high standard of qualification for award of its studentships. As the Committee does not itself select the students for awards, but uses the system of quota and nomination already described, it has stipulated straight-forward and generally acceptable criteria. These are at least an upper second-class honours degree in science or technology, or an equivalent qualification, for a Research Studentship, and at least a lower second-class honours degree for an Advanced Course Studentship. Although the university degree, or its equivalent, is not an infallible test of ability to succeed in research, when taken in conjunction with the opinion of the student's teachers it would seem to be the best generally available test of intellectual suitability for research. The Committee therefore adheres strictly to this standard and allows exceptions only where illness or other unusual circumstances warrant special consideration (See Section II, Tables (b), (c) and (d)).

A TRIAL ARRANGEMENT

16. Apart from recognizing the need for these few latter exceptions, it is realized more generally that the correlation between potential research ability and performance in a first degree examination is unlikely to be perfect, and there are a few graduates with lower second-class degrees who would make better research workers than some with upper seconds or firsts. To deal with such refinements in selection requires more detailed and reliable knowledge of individual cases than could be available in a large national scheme administered centrally: to be workable and equitable, general regulations must lay down simple criteria. However, a small pilot scheme is at present being run experimentally by D.S.I.R. in collaboration with four chemistry research schools to see if a little more flexibility on this question of minimum basic qualifications can be introduced into the selection procedure.

17. For this trial scheme the " First-Year Studentship " has temporarily been instituted; this bears neither the prefix " Research " nor " Advanced Course ", until the end of the first probationary year. The four research schools participating may, if they wish, nominate for studentships a few students with lower second-class degrees if they think that these students are likely to become good research workers. At the end of the first year, each research school is expected to select for normal second-year Research Studentships those who have shown the most research promise; to select for Advanced Course Studentships those whose performance, perhaps mainly on the instructional side during the first postgraduate year, suggests this sort of training would be more suitable; and to discontinue the training of the rest. In this way some students with lower second-class degrees are able to prove themselves suitable for research awards, while some with better degrees but less research ability can be more easily encouraged to take up other scientific work for which they are better suited. To keep the numbers about right there is an understanding between D.S.I.R. and the schools concerned that, in return for this greater flexibility, they will eliminate enough students to ensure that taking one year with another, they receive about the same level of support through D.S.I.R. Studentships as would have been their fair share under the Department's usual arrangements.

ALTERNATIVES TO DEGREES

18. D.S.I.R. is regularly faced with the problem of determining what other qualifications in science and technology, when held by candidates for awards, can reasonably be regarded as acceptable alternatives to good honours degrees. For example it has agreed that the new Diploma in Technology can make a candidate eligible for a Studentship. The specialist sub-committees of the P.T.A.C. are able to offer advice on the standards of various professional Associateships and so forth that might provide acceptable alternatives. Normally the Higher National Certificate and the Higher National Diploma are not accepted (unless supplemented by additional knowledge or experience to provide the same kind of qualification in depth and specialisation as an honours degree).

DIVISION OF RESPONSIBILITY WITH GOVERNMENT BODIES

19. Another set of problems, relating in part to the qualifications required for D.S.I.R. awards, stems from the division of the responsibility for postgraduate awards between D.S.I.R. and other Government bodies. This division has to

take account not only of the proposed subject of the postgraduate training but also of the candidate's qualification. For example, the boundary between the D.S.I.R. Studentship scheme and the Ministry of Education's State Studentship scheme for arts subjects cuts across disciplines such as geography, sociology and psychology. D.S.I.R. supports students who are being trained in certain limited fields within these disciplines, provided they have followed degree courses having an adequate content of science. Also in biology the frontiers between the fields of D.S.I.R. and of the other Government organizations concerned, in this case the Agricultural and the Medical Research Councils, the Development Commission, the Nature Conservancy, and the Ministry of Agriculture, Fisheries and Food, are sometimes unavoidably difficult to define. Therefore D.S.I.R. and the other bodies concerned seek by mutual consultation to ensure that any borderline application gets fair consideration by one of them.

ALLOTMENT TO SMALL DEPARTMENTS

20. The distribution of awards follows procedure already outlined in Section I. In general it is not always easy to provide small departments in universities with D.S.I.R. Studentships through the otherwise generally satisfactory quota system. Often a small department of science or technology has both a small final honours year of undergraduates and also a small research school. If a quota of at least one award every year were to be given to every good-quality small school applying, many awards might needlessly appear to be bespoke at a time when flexibility is desirable, for many of these schools would not be able to produce suitable candidates later in the summer. For this reason a small department often does not receive a quota initially, on the understanding that it can ask for one or more of the D.S.I.R. awards not earmarked by subject and in the gift of the university authorities. If the department fails to secure one of these, it can still turn to D.S.I.R. during the summer for one of the awards held in reserve.

ALLOTMENT TO OTHER INSTITUTIONS

21. Another problem concerning the allocation of Studentships arises in relation to the colleges of advanced technology and other technical colleges where the encouragement of postgraduate training is highly desirable. In colleges which give instruction up to the level of an honours degree or the Diploma in Technology, or beyond, research and teaching should be in progress side by side. In many such colleges research of a high standard is to be found, and its volume is growing. D.S.I.R. is ready to help all colleges teaching up to the degree level or its equivalent to establish postgraduate research groups, however small. From the inception of its Research Studentship scheme D.S.I.R. has been prepared to make its awards tenable in technical colleges as well as in the universities, and therefore more recently in the new colleges of advanced technology. (See also Chapter 3, Section I, paragraph 17, and Section II, paragraph 3). In general the demand for awards for these colleges has been small, and the numbers of D.S.I.R. awards taken up outside the universities remains only a small proportion of the whole.

22. There are several reasons for this. Firstly, universities in general and their degrees enjoy by tradition a prestige and a status not yet generally accorded to newer institutions and their qualifications. Therefore there is a tendency for many able students, given the opportunity, to prefer not only to take their

undergraduate courses at universities but also to remain in universities for postgraduate training. Secondly, research in British universities has a high reputation, and probably most young honours graduates seeking a postgraduate training in research tend to think in terms of training in a university. (For both of these reasons some students like to move from a C.A.T. to a university on graduating). Thirdly, it is likely that the doctorate which the universities offer to denote a successful training in research is more attractive than the alternative qualifications offered by the C.A.T.s. and technical colleges (the external Ph.D. degree of London University not being generally available). It is too early as yet to see to what extent the new higher qualification of the National Council for Technological Awards, "Membership of the College of Technologists", will reverse this trend, and how attractive the recently established Research Diploma of the Royal Institute of Chemistry will prove as an alternative to the Ph.D. degree in chemistry.

23. There are good facilities, particularly in terms of equipment, for research training in many Government and other research establishments, but little use is made of D.S.I.R. Studentships in these places. Although London graduates can work for the external London Ph.D. the lack of an attractive qualification that is generally available may be a reason for the reluctance of postgraduate students to use such laboratories. Occasionally arrangements are made for postgraduate students to work in these laboratories, arrangements which are quite acceptable to D.S.I.R. for holders of its Studentships and Fellowships. D.S.I.R. would be glad to receive more students, whether holding its awards or not, to work in its own laboratories.

SECTION IV: THE VALUE OF AWARDS

VALUES IN 1956–1960

1. Table (a) shows the values of D.S.I.R. Studentships during the period covered by this report. These payments are free of income tax.

Table (a)

The Values of D.S.I.R. Studentships (£s per annum)

	From 1st Oct. 1953 to 30th Sept. 1957	From 1st Oct. 1957 to 30th Sept. 1958	From 1st Oct. 1958
Students living in lodgings, college, or hall:			
Oxford or Cambridge	325	380	420*
London	325	360	400
Elsewhere	285	310	340
Students living with parents:			
London	245	260	285
Elsewhere	245	245	270

* At Oxford and Cambridge D.S.I.R. pays only half the college dues or establishment charges and the students are required to pay the remainder, an average of about £20 a year.

2. In addition to these basic rates of award students may be given certain other allowances. One of the largest of these is the allowance, first introduced in 1956, given to students with two years postgraduate experience in industry. The purpose of this increment is to attract graduates, especially engineering graduates, back to the universities for postgraduate study after they have had some industrial experience, in the belief that they gain more from academic training at that stage in their careers. For students who have reached the age of 23 years by 1st October the allowance is £100 p.a. during the succeeding twelve months; 24 years, £150 p.a.; and 25 years or more, £200 p.a. In 1960, 36 out of 1293 students taking up D.S.I.R. Research Studentships received these allowances, compared with 19 out of 801 in 1957.

3. In 1958 D.S.I.R. started for the first time paying special allowances to older students with dependants. At present these allowances are payable only to students who are over 25 before they are given an award, or alternatively were supported by their own earnings for the two years immediately before taking up a studentship. Where the dependant is a wife or child the student must be married before his award begins. The reason these allowances have been limited to the older student is that D.S.I.R. does not wish to encourage students in their early twenties to take on family responsibilities at the public expense. The main purpose of these allowances, like those given for industrial experience, is to make it easier for a graduate who has a job to return to the university for further training; and they are also intended to ease the path of the older student who has had his career interrupted in one way or another. Among the 1293 students who took up awards in 1960, 13 were given these allowances. The maximum rates of allowance payable are £160 p.a. for an adult dependant, £55 p.a. for the first child, £35 p.a. for the second child, and £30 p.a. for any subsequent child. These rates are subject to deductions for any income the dependants have in their own right, and are also limited by the provision that a student may not be paid more than he would receive if he were a D.S.I.R. research fellow.

4. D.S.I.R. also pays the student's fees, the cost of three return journeys in any one academic year between his home and university if the return fare is at least £1 10s. 0d., and contributes towards approved travelling and subsistence expenses in connection with his studies.

5. In addition D.S.I.R. Students can supplement their awards by earnings from university and college teaching or demonstrating. Such work is increasingly accepted as a normal part of a research student's work.

6. In 1958, following increases in the values of other fellowships of comparable standing and in academic salaries, the scale for D.S.I.R. Fellowships was set at £700 to £850 a year. At the same time it was decided that exceptionally able fellows could be paid up to £1000 a year. By the end of 1960 two D.S.I.R. Fellows had been paid more than £850 a year under this provision.*

REVIEW OF THE VALUE OF AWARDS

7. When in 1958 the Postgraduate Training Grants Committee (now the P.T.A.C.) found it necessary to increase the value of D.S.I.R. awards to allow for rises in the cost of living and changes in the values of undergraduate awards, it found that the increase in the Department's responsibilities had produced a

---

* With effect from 1st October 1961 the values of D.S.I.R. Fellowships were increased by £100 a year.

different situation from any that faced the earlier committee. D.S.I.R. was no longer one among many awarding bodies in its field: it was the main body, and any lead it gave was likely to be followed by others. Therefore the P.T.G.C. felt that it needed a thorough re-examination of the principles underlying the value of D.S.I.R. awards in order to determine how the general levels of the value of D.S.I.R. awards should be fixed, the methods by which the value of D.S.I.R. Studentships and Fellowships should be reassessed from time to time, and to what extent studentships should have different values according to the university attended. Again, the extent of other differences between the various levels of award to D.S.I.R. Students (for example between awards to students living with their parents and those in lodgings) and the question of paying special allowances to students with dependant relatives also required examination. Accordingly the Committee set up a sub-committee with the following membership to look into these matters:

Chairman: Sir Eric Ashby (lately Vice-Chancellor of Queen's University Belfast, and now Master of Clare College, Cambridge).

Members: Professor P. M. S. Blackett, F.R.S. (Professor of Physics, Imperial College of Science and Technology, London).

Dr. J. W. Cook, F.R.S. (Vice-Chancellor of the University of Exeter).

J. S. Fulton, Esq., (Lately Principal of the University College of Swansea; now Vice-Chancellor of the University of Sussex).

Professor E. C. Stoner, F.R.S. (Cavendish Professor of Physics, University of Leeds).

Professor C. E. Tilley, F.R.S. (Professor of Mineralogy and Petrology, University of Cambridge).

ACTION ON THE ASHBY SUB-COMMITTEE'S PROPOSALS

8. The Ashby Sub-committee presented an Interim Report, covering the values of Studentships in March, 1960, and a Final Report, covering its whole field, in November, 1960. These Reports were adopted by the Postgraduate Training Awards Committee (P.T.A.C.) and sent to the Research Council for consideration. The consideration of the Final Report by the Research Council falls outside the period covered by this report, but as this matter is of such importance to D.S.I.R. Students and to their universities and colleges, a brief note on the implementation of the Ashby proposals is given here.

9. The Research Council accepted the recommendations made in the Report in principle, with one exception; the Report made a number of recommendations intended to give D.S.I.R. Students the national insurance privileges received by persons in employment, which the Council did not feel should be adopted at present. While accepting the Report in principle, the Research Council decided that changes were needed in many of the actual figures (e.g. for income to be ignored in assessing the values of Studentships) put forward by the Sub-committee. Also changes in the cost of living and starting salaries in employment took place after the Report was drawn up which made the values of Studentships needed to implement the Sub-committee's recommendations on principles higher than the figures put forward in the Report.

10. The acceptance of the Ashby Report by the Research Council did not, however, mean that its recommendations could be implemented immediately.

D

The D.S.I.R. Studentship Scheme is only part of the arrangements for providing university awards from public funds, and any change made by D.S.I.R. may have an effect on other schemes of awards. It was therefore necessary to ensure that awards made by D.S.I.R. were in reasonable conformity with the general practice of the Government in making similar types of award.

ABRIDGEMENT OF THE ASHBY REPORT

11. Some of the sections of the report of more general interest are given in condensed form below.

GENERAL LEVEL OF AWARDS: GENERAL PRINCIPLES

12. The Sub-committee on the Value of Awards reaffirmed that the purpose of D.S.I.R. awards was to give opportunities to the most promising graduates in science and technology each year to pursue advanced study, or to learn the techniques of research, in both their own interests and those of the country as a whole. The high quality of the students who received awards was evident from the fact that about 40 per cent of the graduates in science and technology who received first class honours degrees became D.S.I.R. Research Students; and in the period considered in physics, chemistry and mathematics the proportion of first class honours graduates who received D.S.I.R. awards exceeds 60 per cent.

13. The philosophy originally underlying the early D.S.I.R. awards (then called Maintenance Allowances) was that they should be just enough to support a student (taking into account other sources of income available to him). The Sub-committee felt that this philosophy was not sound in view of the quality of men who receive awards and of the widespread opinion that young scientists should be encouraged to cultivate interests outside science. Students of such high quality needed more than a bare subsistence allowance if they were to develop into useful citizens and successful professional scientists: they should not only have adequate food and reasonably comfortable rooms in which they could both work and relax, but also be able to spend a modest amount on such items as books, music, the theatre, travel and sport. Many of them had to deny themselves these more expensive cultural activities during their undergraduate careers, and it was psychologically important that the award of the D.S.I.R. Studentship should bring with it a modest expansion of such activities. Therefore the Sub-committee recommended that the value of D.S.I.R. Studentships should be sufficiently high to allow the students a standard of living rather higher than that enjoyed by most undergraduates of comparable ability.

14. A survey conducted by D.S.I.R. showed that most D.S.I.R. Students living in colleges, hostels or lodgings in London and Cambridge had a reasonable standard of comfort in 1958–9. London students living in furnished flats or bed-sitting rooms spent an average of £249 a year on their main living expenses, rent, food, fuel and light, laundry and travel to college. This left the student who had no earnings from teaching or demonstrating with £151 (38 per cent of his award of £400) to spend on clothes, entertainment, holidays, books and other items. This seemed to the Sub-committee an adequate standard of living for postgraduate students. As most D.S.I.R. Research Students have extra money, either from teaching and demonstrating or from increments for industrial experience, most of those in London had a standard of living above this level.

15. The Sub-committee recommended that if prices rose a watch should be kept on D.S.I.R. Students' standards of living, which should not be allowed to slip below the level found in D.S.I.R.'s survey of the position. Also any significant rise (by more than 5 per cent) in the average standard of living in the country as a whole or any rise in the standard of living of undergraduates should be taken into account in considering the value of D.S.I.R. Studentships. These recommendations were intended to override those on the relationship of D.S.I.R. Studentships to starting salaries in employment should any conflict arise between the two sets of recommendations.

RELATING AWARDS TO STARTING SALARIES

16. D.S.I.R. Studentships helped to provide industry, the universities, Government departments and various research organizations with the essential supply of scientists and technologists who had received postgraduate training. Unless the awards were sufficiently attractive the supply would be inadequate. The rate of award therefore would have to be sufficiently high to attract enough of the most able graduates against the competition of the starting salaries they could obtain in employment. The Sub-committee did not suggest that D.S.I.R. should pay its students as much as they would obtain in employment as they thought it right that students should make some sacrifice for the benefits they received, and there was always likely to be a sufficient proportion of able students willing to make a certain sacrifice. But if the sacrifice was too great postgraduate training might become a second choice instead of a first choice for too many graduates of ability. Therefore the Sub-committee recommended that the rates of award of D.S.I.R. Students should be kept in a steady relationship to starting salaries in employment; it was in the public interest that there should be a sufficient inducement to accept D.S.I.R. awards.

17. The Sub-committee estimated that to put this recommendation into effect the rate of award to D.S.I.R. Students living in lodgings in London should not differ markedly from 70–75 per cent of the average net salary (after such deductions as income tax) they would be likely to get in employment (taking all branches of science and technology together).

ENGINEERS

18. A number of heads of university departments of engineering had expressed concern at the relatively small number of engineers who either stayed at universities for postgraduate study or research after taking their first degrees or returned to them later. Concern was felt on two grounds: firstly, some engineering departments had difficulty in running a research school of reasonable size; and secondly, there was a feeling that certain parts of the engineering industry did too little research, that they should be encouraged in the national interest to do more, and that the provision of more graduates trained in research was one way of helping to make this possible.

19. In 1959, D.S.I.R. gave 169 Research Studentships and 92 Advanced Course Studentships to engineers. These represented 18·2 per cent of the Research Studentships, 36·7 per cent of the Advanced Course Studentships, and 22·1 per cent of both kinds taken together. However, other bodies besides D.S.I.R. supported postgraduate students at the universities, and engineers were supported by industry more often than natural scientists. In fact 30 per cent of the British students starting postgraduate training in science and technology in

1958–59 were engineers. This seemed a satisfactory figure as 29 per cent of the honours degrees in science and technology awarded in 1958 were in technology. The problem seemed to be not that these students were unwilling to receive postgraduate training but that a large proportion of them were unwilling to receive research training.

20. The Sub-committee thought that any difficulty in persuading engineers to remain three years at universities to do postgraduate research work should not be attributed primarily to shortcomings in D.S.I.R. awards. It was commonly held that an engineer had not completed his training until he had had at least two years experience in industry, and so a proportion of engineering graduates preferred to spend a period in industry before starting research training. This was bound to reduce the number of students taking research training. After a period in industry the student was older, and so more likely to be married and have a family. The salary he would have had to forego would be greater, and there was more sacrifice in giving up for a while a scale of living to which one had become accustomed than in postponing its beginning. Also, once the student was in employment inertia acted against his return to the university, whereas immediately after graduation it would tend to keep him at the university. It was because of such considerations that D.S.I.R. offered an extra allowance to students with two years of approved postgraduate experience in industry (see paragraph 2, page 40).

21. Of the 261 men taking up D.S.I.R. Studentships in engineering subjects in 1959, 216 came straight from their undergraduate studies. The problem of attracting more of such students differed in some ways from the problem of attracting students from employment. Some heads of departments had suggested to D.S.I.R. that their difficulty in recruiting these students was due to the high starting salaries offered by industry and that the answer was for D.S.I.R. to offer more money either to all students, or at least to engineers. The Sub-committee considered these suggestions but concluded that the reasons for the difficulties these engineering departments were meeting were probably more fundamental and that raising the values of D.S.I.R. Studentships in engineering would not solve them. For this reason, and because it was not, as a matter of general principle, in favour of students who had been trained in different branches of science being paid at different rates, the Sub-committee did not recommend any increase in the value of awards specifically to attract more engineers.

RATES FOR DIFFERENT PLACES

22. Before the survey of D.S.I.R. Students' expenditure and standards of living was carried out it was thought that at any university there might be a range of possible costs of living corresponding to a range of students' standards of living, and this was confirmed by the results of the survey. Because of this the Sub-committee concluded that the production of a single figure for the cost of living at a given university involved a large element of subjective judgment on the standard of living that is appropriate at that university. If such figures were then used to determine values of awards there was a risk that, as different universities might reach different conclusions, rates of award would vary on that account alone. This might partly explain the perpetuation of the higher standards of living at Oxford and Cambridge, and the lower standards at provincial, Welsh and Scottish universities—a difference that appeared to do a

disservice to the prestige and status of the provincial universities and to aggravate, for undesirable reasons, the attraction of Oxford and Cambridge over other universities. As a matter of principle the Sub-committee recommended that a D.S.I.R. Student should be able to afford roughly the same standard of living regardless of the university he chooses to attend.

23. The special survey carried out on behalf of the Sub-committee also showed that it cost a D.S.I.R. Student approximately the same to live at a given standard regardless of the university or college he attended, and that D.S.I.R. Students in provincial, Welsh and Scottish universities had a markedly lower standard of living, as a result of the lower value of their awards, than those at Cambridge, London and Oxford. As the standard of living of the student living in lodgings in London was found by the survey to be satisfactory (see paragraph 14, p. 42) the Sub-committee came to the conclusion that the rates of award to students at other universities should be enough to allow them a similar standard of living (i.e. the London rate of £400 per annum).

24. The Sub-committee thought that the assessment of what it costs to maintain a given standard of living in each town (which would have to be made periodically to give effect to its recommendations) should be done by a single body, and recommended that D.S.I.R. itself should in future make such assessments, in consultation with other interested bodies, when needed.

STUDENTS LIVING AT HOME

25. The rates of award to D.S.I.R. Students living at home are based on the principle that the students should be able to contribute enough towards the household expenses for his parents to be neither in pocket nor out of pocket. His parents should not expect to make a landlady's profit, nor should they normally expect any contribution towards the expenses they will have to pay in any case (rent, rates, etc.), but they should be paid for the extra cost of food, laundry, etc. arising from the student living at home. Accordingly students in London are paid £285 (£115 less than those living in lodgings) and in the provinces £270 (£70 less than in lodgings). The principle seemed generally fair.

26. The adequacy of the present "at home" rate was difficult to determine, especially as many students did not make a fixed contribution to the expenses of their home. Further, most parents received a tax allowance for a son or daughter with a D.S.I.R. Studentship, which was worth nearly £60 at the standard rate of income tax, and a student living at home was more likely to receive some benefit from this than a student who was living away from home. D.S.I.R. Students living at home in the provinces and Scotland seemed to be able to spend rather more than other D.S.I.R. Students on such things as entertainment and holidays. In London it was the student living in lodgings who was able to spend more. This suggested that the difference between the "lodgings" rate and the "at home" rate should be less than the difference of £115 in London and greater than the difference of £70 in the provinces. Again, the average amount paid for lodgings with part board in London was £3 10s. 0d. a week for about 47 weeks in the year. Therefore if a student living at home was to spend the same amount as his fellow students on lunches in college, clothes, entertainment and so on, he could afford to give his parents only £1 a week. This did not seem enough to cover the cost of his food, and so the Sub-committee recommended that the value of the award for students living at home should be increased to £300 a year, wherever the homes might be.

SPECIAL ALLOWANCES AND INCREMENTS

27. Two sorts of special addition to the value of the award may be given to students at present—allowances for postgraduate industrial experience and dependants' allowances. During the period under review 60 students were receiving these allowances (see paragraphs 2, 3 and 20) and the Sub-committee recommended that these allowances should be continued.

28. The current system of allowances for postgraduate experience does not give a student any extra money after the year in which he reaches the age of 26. On the other hand, the present increments of £50 a year (tax free) were somewhat larger than a graduate could expect in employment. Therefore the Sub-committee felt justified in recommending that the scale of increments should be lengthened and the size of each increment reduced. This meant that students who have reached the age of 23 years by 1st October would be paid an additional £100 p.a. during the succeeding twelve months and an additional £25 per annum for each year of age over 23, up to a maximum of £200 p.a. altogether.

29. The Sub-committee recommended that these allowances should not be given too widely and that there should be no further extension of the conditions under which the increments could be given. Also a new smaller allowance referred to in paragraph 34, was recommended for certain classes of older students and as a consequence it was recommended that the allowance for postgraduate industrial experience should no longer be given to students with only one year of approved postgraduate experience.

DEPENDANTS' ALLOWANCES

30. These allowances (see paragraph 3) are additional to the national Family Allowances which are £20 16s. 0d. a year for the second child and £26 for each subsequent child. Deductions are made for any income the dependants have in their own right.

31. The age limit of 25 was imposed originally because it seemed right for the younger man, but not for the older man, to forgo the founding of a family during his period of training at the public expense. The Sub-committee agreed with this general principle, but, as it did not feel it was reasonable that a man who was 25 on 30th July should be old enough to have a family while a man a week younger should not be old enough to have a family until he had reached the age of 28½, it recommended that all D.S.I.R. Students should become eligible for dependants' allowances on reaching the age of 25.

32. Dependants' allowances are made only to students who are already married in order to deter other students from taking on such private commitments at the public expense. In the Sub-committee's view the rules D.S.I.R. applied did not however, have this effect entirely. Since a wife's income is set against such an allowance students rarely claim these allowances until their wives are prevented by having children from going out to work. It therefore seemed to the Sub-committee that the burden on public funds was usually not the wife but the children, and that under the regulations students who were already married were able to take on these burdens at the public expense.

33. The main objection to this part of the present regulations was that it was likely to discourage older men from taking up awards. D.S.I.R. wished to encourage men with a few years' industrial experience to return to the universities.

In many subjects such men could get more value from their training and bring more benefit to the universities, and the product of the training was of greater value to the country. The possibility of getting a dependant's allowance, should it be needed, was one of the conditions of award likely to influence the graduate in deciding whether to take further training or not, and so it was desirable to offer these allowances to all older married men. The Sub-committee took the view that D.S.I.R. Students should be treated as responsible adult citizens, and that the rate of award should make it possible for those aged 25 and over to marry and have children if they wished to do so. It therefore recommended that all D.S.I.R. Students over the age of 25 should become eligible for dependants' allowances on marrying and that dependants' allowances should be available to students under 25 years of age who married during a period of at least one year in which they were supporting themselves largely through their own earnings.

INCREMENTS FOR OLDER STUDENTS

34. The Sub-committee also recommended that older students should be given an extra allowance at a lower rate than the allowance for approved postgraduate experience in industry. When such a student had reached the age of 23 years by 1st October he would be entitled to receive an additional £50 p.a. during the succeeding twelve months; at 24 years, £75 p.a., and at 25 years or more £100 p.a. provided that he had substantially supported himself for at least two years. This allowance would be an alternative to a dependants' allowance, and students eligible for both allowances would be given only the larger one. This allowance would not be given to any student eligible for the allowance for two years' approved postgraduate experience in industry.

DEDUCTIONS FROM D.S.I.R. AWARDS

(i) General

35. D.S.I.R. awards have always been intended primarily to supplement and not to replace the student's other income, in order to bring the total to a sum which gives him an adequate standard of living.

Among the reasons for this traditional attitude are:

(a) The awards are not a fixed salary, but an education grant enabling a student to stay longer at a university in order to get further training if he wishes. If he could do it without there would be little need for the grant.

(b) This system enables the largest possible number of able students to be given support to an adequate standard for any given expenditure of public funds.

36. The Sub-committee thought that this general principle was essentially sound and should continue by and large to prevail. Strictly applied it would result in all other income of the student being deducted from the value of his award. There are, however, other considerations to take into account before deducting income from certain sources; for example, if all earnings from teaching are deducted from the value of the award students will be discouraged from doing work that is often beneficial to their studies. Therefore in practice it is necessary to compromise between opposing principles in order to decide whether and how much to deduct from the value of the award for certain types of income,

(*ii*) *Earnings for Teaching and Demonstrating*

37. Until 1953 half of all fees D.S.I.R. Students earned by teaching or demonstrating were deducted from the values of their awards. Since then students have been allowed to keep £50 a year of such earnings before their awards are reduced, and the proportion of Research Students doing teaching or demonstrating, perhaps partly in consequence, rose from half in 1952/53 to four fifths in 1958/59 (see Chapter 2, Section II, paragraphs 29–31). However, there is now a tendency for students to earn exactly £50 a year, or a little less, either because the universities consider that it is appropriate to pay this amount—the largest sum that may be earned without the award being reduced—or because students are deliberately limiting the amount of teaching and demonstrating they do. For this reason and because of the fall in value of money since 1953, the Sub-committee recommended an increase to £75 in the amount which D.S.I.R. Students are allowed to earn without deduction (subject to the overall limit given in paragraph 42 below).

(*iii*) *Other Earnings*

38. D.S.I.R. Students are not at present permitted to undertake any work other than teaching, demonstrating, and occasionally certain other forms of work directly related to their training. The Sub-committee felt there were further kinds of paid work students might do in their spare time which would be harmless in moderation. Therefore it proposed that for a trial period of two or three years D.S.I.R. Students should be allowed to undertake up to six hours a week of such work where this would not interfere with their training. It should be necessary for them to obtain the prior consent of both their supervisors and D.S.I.R. Vacation work, other than work necessary for a student's training, would be permitted only when it was compatible with the recreational purposes of a holiday. No deduction from the student's award should be made for the first £30 of such earnings in any one year (subject to the overall limit given in paragraph 42 below). Half the remainder should be deducted.

(*iv*) *Prizes*

39. It seemed desirable that students should be encouraged to compete for prizes offered for specially meritorious work and that they should be allowed to benefit to a certain extent from any money prizes won. It was recommended that students should be allowed to benefit by up to £75 a year, on a tapering scale, from any prizes for work in their own subjects.

(*v*) *Scholarships*

40. Some university and college scholarships are very like prizes in that they are awarded competitively and to the most able and hard-working scholars. There has been an indication that because students already holding D.S.I.R. Studentships or State Studentships have not been able to benefit from gaining other scholarships, the quality of the entrants for certain scholarships which once had a high status has declined. On the other hand very few university or college scholarships are affected in this way. Many university postgraduate scholarships in science and technology are of roughly the same value as D.S.I.R. awards and are regarded simply as an alternative means of support; and in fact in 1958–59 some 690 postgraduate students of science or technology were supported by college or university awards. Partly because it might embarrass the universities if a student were able to obtain more money by holding both a

D.S.I.R. award and a university award than by holding only one of them, the Sub-committee recommended that the full value of any other studentship held by a D.S.I.R. Student should in general continue to be deducted from the value of his D.S.I.R. award. Where, however, the other award (regardless of its name) was more in the nature of a prize than a scholarship, being awarded competitively for outstanding merit and not stipulating further study which the D.S.I.R. Studentship is intended to support, it should if appropriate be treated as a prize for the purpose of deciding the amount of deduction.

(*vi*) *Private Incomes*

41. The Sub-committee found that there were variations in the practice adopted in relation to various types of higher education awards, in making deductions from the awards in respect of private income, other than gifts, but including income received under covenant. The Sub-committee considered that the existing arrangement by which all but the first £5 of any such income was deducted from the value of any D.S.I.R. Student's award was consistent with the principle that the awards are intended to supplement rather than replace a student's other means so as to give an adequate standard of living (see paragraph 35). Taking into account practice in related fields, however, the Sub-committee decided to recommend a small increase—to £25—in the amount of net private income that a D.S.I.R. Student might have before any deduction was made from the award; this is subject to the overall limit set in paragraph 42 below.

(*vii*) *Recommendations*

42. Taken together the various concessions recommended could result in some students having incomes appreciably above the levels recommended as desirable. To maintain the essential principle underlying the awards, the Sub-committee recommended that an overall limit (initially of £75) be put on the amount a student might freely retain from private income and all earnings combined (but not prize money) before any deduction was made from the value of his award. No deduction should be made from a D.S.I.R. Student's award for the first £75 of private income and earnings, of which not more than £25 should be private income and not more than £30 income from work other than teaching or demonstrating, in each year of his award. All remaining private income, and half of any remaining earnings, should be deducted from the value of the award. In addition a student should be allowed to retain the first £50 of money from prizes and half of the next £50 in any year. Deductions for periods of less than 12 months should, as at present, be calculated *pro rata*.

STUDENTS' FEES

43. At present D.S.I.R. pays, with a few exceptions direct to the university or college concerned, all compulsory fees. In 1958–59 D.S.I.R. paid £102 000 in fees on behalf of its students—an average of £68 for each Advanced Course Student and £53 for each Research Student. There are large variations between different universities in amounts charged for fees, from £127 per student at one of the colleges in Oxford to £25 per student at one of the London colleges, and £12 at one of the colleges of advanced technology. The average paid for D.S.I.R. Students at Oxford and Cambridge was £93, and at London £38 (it would be fair to add about £5–£7 to each of these figures to allow for the examination fees paid separately); at other universities in Great Britain it was £48.

FEES OTHER THAN AT OXFORD AND CAMBRIDGE

44. Figures for 1958–59 show that the fees received by the universities and colleges in receipt of a grant from the University Grants Committee (U.G.C.) covered 11 per cent of their recurrent expenditure. It is not known, and it would probably not be possible to estimate separately, what percentage of the cost of training D.S.I.R. Students was covered by the fees paid on their behalf, but it is quite clear that the fees covered only a small part of this cost. In these circumstances the fees for D.S.I.R. Students cannot be considered excessive.

45. In view of the wide variation in the scales of fees charged for D.S.I.R. Students by different universities and colleges, the Sub-committee suggested that some collective thought might be given by those concerned to the question of whether a greater degree of uniformity in the level of fees is desirable.

FEES AT OXFORD AND CAMBRIDGE

46. At Oxford and Cambridge the universities receive grants from the U.G.C. but normally the colleges do not. The university has virtually the sole responsibility for the teaching of graduate students, but every student must be a member of a college and therefore the college has certain administrative and disciplinary responsibilities for a student. The colleges collect both the university fees, which they pass on to the University, and the fees they levy for their own use. In 1958–59 the colleges retained an average of over £60 for each D.S.I.R. Student. Payments of this size—greater than the fee paid for all purposes at most other British universities—made to bodies which have little responsibility for teaching D.S.I.R. Students seemed to the Sub-committee to call for closer examination.

47. The Sub-committee considered why the level of these college fees was so high. One obvious explanation was that the various facilities paid for by these fees were provided on a more generous scale at Oxford and Cambridge. The Sub-committee decided that where the amenities which universities offered to D.S.I.R. Students were below the standard of Oxford and Cambridge it would like to see the standard raised. It also recommended that D.S.I.R. should continue paying the existing levels of college fees at Oxford and Cambridge and that if any of the colleges charging above the average applied at any time in the future for higher fees, D.S.I.R. should consider this application critically in the light of the existing general level of fees.

48. The Sub-committee also considered the Department's practice of paying directly to Oxford and Cambridge colleges only half of their establishment charges, the remainder being paid indirectly by being included in the value of the students' grants. It did not think that this arrangement offered any substantial advantage, whereas if D.S.I.R. were to pay this fee in full the value of awards at Oxford and Cambridge could be reduced by £20 to the level that the Sub-committee was recommending should be paid at other universities. The Sub-committee therefore recommended that this change should be made.

RESEARCH FELLOWSHIPS

49. When the P.T.G.C. reviewed the scale of payment for D.S.I.R. Research Fellows in March 1958 it considered the scales of payment of other research fellows and of university teachers of about the same ages. It decided to adopt for D.S.I.R. Research Fellows the scale then being paid to university assistant

lecturers (£700–£850). However, D.S.I.R. Research Fellowships have been worth less than assistant lecturerships at universities in the following respects:

(a) Universities normally pay an employer's contribution to F.S.S.U. for the assistant lecturer, but D.S.I.R. pays this only when the Fellow has previously been a member of F.S.S.U.

(b) Assistant lecturers are eligible for family allowances additional to the normal scale. These are £50 a year for each child.

(c) Assistant lecturers in London receive a special London increment of £60.

(d) Assistant lecturers pay National Insurance contributions at the rate applicable to employed persons; D.S.I.R. Fellows pay a higher rate applicable to self-employed persons and are not eligible for all benefits.

RECOMMENDATIONS ON THE VALUE OF FELLOWSHIPS

50. In the Sub-committee's view D.S.I.R. should be able to offer the able Fellow enough to encourage him to stay in Britain instead of taking his high intelligence and his skill (acquired usually at great expense to the British taxpayer) abroad to countries offering larger stipends. The Sub-committee decided that D.S.I.R. should be offering more money to at least the more able candidates because (a) many of the abler candidates offered D.S.I.R. Fellowships in recent years had turned them down, (b) the value of D.S.I.R. Fellowships was below the average of other fellowships of comparable status and (c) many British holders of research degrees were attracted to North America by the higher value of other fellowships there.

51. As a matter of general principle it recommended that in fixing the scale within which the payments to individual Fellows should lie, D.S.I.R. should have regard to the following two comparable scales, of which the first was considered the more important:

(a) University assistant lectureships, taking into account the various normal increments and fringe benefits received;

(b) the range of values within which lie most of the post-doctoral fellowships in science and technology awarded by other bodies in the United Kingdom.

52. With these principles in mind the Sub-committee recommended that D.S.I.R. Research Fellows should normally be paid on the scale £800–£950 per annum. In addition family allowances of £50 a child (but not exceeding £150) should be paid, and Fellows working in central London should, like assistant lecturers, be paid an extra £60. When the Fellow is of more than usually outstanding ability it should, as at present, be possible to increase the value of his Fellowship beyond the normal scale; the maximum in this case should be £1200 p.a. including allowances. These scales were recommended on the assumption that it would prove possible to provide superannuation for the Fellows (as recommended below).

53. In order to remove certain disadvantages D.S.I.R. Research Fellows suffered in respect of their National Insurance, the Sub-committee recommended that an attempt should be made to find a way in which they could be counted as employed persons (perhaps by the universities taking on this responsibility as they did for certain other research fellows) but without D.S.I.R. assuming the legal obligations of an employer.

SUPERANNUATION OF FELLOWS

54. On behalf of assistant lecturers the universities make contributions under the Federated Superannuation Scheme for Universities (F.S.S.U.) equivalent to 10 per cent of their salaries. Similar contributions are paid by the awarding body on behalf of many research fellows, but not normally for D.S.I.R. Fellows. However, as a special concession D.S.I.R. made these contributions on behalf of its Fellows when they were already members of F.S.S.U. before taking up their Fellowships so that there would not be a gap in their premiums.

55. As most D.S.I.R. Fellows received their Fellowships immediately after they held a Research Studentship, few of them qualified for these D.S.I.R. contributions to F.S.S.U. It was considered not to be in the national interest that the superannuation received by a man who held a D.S.I.R. Fellowship before taking a teaching post should be less than it would have been if he went earlier to university teaching. Further, the Sub-committee felt that all D.S.I.R. Fellows should be treated alike whether or not they were already covered by the F.S.S.U. system. It therefore recommended that D.S.I.R. should come into line with most other bodies offering fellowships by providing for the superannuation of its Fellows or correspondingly increasing the value of their awards. Of these two alternatives the former was preferred.

RELATIONSHIP BETWEEN A FELLOW AND HIS UNIVERSITY OR COLLEGE

56. The recommendations on the superannuation provision for Fellows and their National Insurance implied a relationship between the Fellow and his university or college that would be rather different from the existing one. The Sub-committee proposed that when a university or college endorses an application for a D.S.I.R. Fellowship it should accept an obligation to undertake the responsibilities (though not the cost) of acting as his employer. D.S.I.R. would pay to the university or college an amount sufficient to cover the Fellow's award, insurance and superannuation, and the university would in its turn pay the Fellow. Under a relationship of this kind the Fellow should not, as has sometimes happened, have to pay bench charges or similar fees. Certain other fellowship schemes are at present operated on rather similar lines.

57. On the other hand the obligations should not in the Sub-committee's view all be in the one direction, and the Fellow should in return be obliged to do a certain amount of teaching or demonstrating for his department if required (up to the present limit of six hours a week) without expecting any payment for this work. This, too, is a feature of certain other fellowships. The Department's requirement that D.S.I.R. Fellows should be paid for this work was intended to provide them with some encouragement to undertake it, but the encouragement had not been very effective and only about a quarter of D.S.I.R. Fellows had done such work in the previous two years. The Sub-committee hoped that under the arrangements proposed more D.S.I.R. Fellows would gain teaching experience and help their universities.

Chapter 3

Research Grants

SECTION I: THE D.S.I.R. SCHEME

PURPOSE OF SCHEME

1. As explained in Chapter 1 D.S.I.R. seeks to encourage research in science and technology in universities, colleges and similar institutions through the award of research grants to investigators of acknowledged standing. These grants are awarded in response to applications from the investigators to enable them to initiate or develop specific investigations of timeliness and promise, to enter new or modified fields of research, or to take advantage of developments in apparatus offering improved techniques in lines already established. The grants are used to provide equipment, assistance, materials and services and costs of travelling, where these are beyond the normal resources of the university. In general it is intended that a grant shall provide initial support for a research project which, if it flourishes, can eventually be assimilated by the university. These grants are to be distinguished from research contracts which are placed with universities by D.S.I.R. and other Government establishments as part of their own programme of work.

POST-WAR EXPANSION

2. In 1945 at the end of the War D.S.I.R. decided that its pre-war scheme of research grants should continue basically unchanged. The Advisory Council affirmed the view that "the Department's policy of making grants for general programmes of research formulated by the leaders of research teams, which can be spent in the way which seems best to them, is generally felt to be much more effective than any system of placing research contracts for researches planned by the Department itself". D.S.I.R. expenditure on research grants for science and technology rose steeply when World War II ended and the staff and facilities of universities and colleges ceased to be engaged upon work connected with the war. In 1945–46 the expenditure was £18 100, and two years later it was £204 400. By 1955–56 it had risen to £373 000 and by 1959–60 to £857 918 (excluding expenditure on human sciences and space research grants).

SETTING UP OF THE RESEARCH GRANTS COMMITTEE

3. Shortly before the D.S.I.R. Act set up the Research Council in 1956, a policy of increased funds for research grants and training awards was reflected in a change in the relevant D.S.I.R. committee structure. The forerunner of the Research Council—the Advisory Council—had set up two committees for this purpose, the Scientific Grants Committee and the Nuclear Physics Committee; the former was responsible for advising on D.S.I.R. Studentships and Fellowships as well as on research grants, and the latter only for grants for large machines for accelerating nuclear particles. In 1956 the retiring Advisory Council appointed a separate Postgraduate Training Grants (now Awards) Committee (P.T.G.C. now P.T.A.C.) to advise on Studentships and Fellowships, and set up a Research Grants Committee (R.G.C.) to advise on research grants in all branches of science and technology within the Department's province,

including nuclear physics, but excepting the human sciences, for which, a year later, the Human Sciences Committee (H.S.C.) was appointed. This change reflected the Advisory Council's view that D.S.I.R. required more specialised advice on the training and research grants respectively and that research grants for nuclear physics should be considered as a part of the general support for all branches of science and technology.

COMPOSITION OF THE COMMITTEE

4. The Chairman of the R.G.C. is one of the academic members of the Research Council (from its inception in October 1956 it was Professor P.M.S. Blackett, who was succeeded in October, 1960, by Professor C.E.H. Bawn). Two or three other Council members also sit on the R.G.C., and the remaining members are eminent scientists, able between them to provide experience embracing the scope of the Department's interests. This normally permits each of the nine subject Sub-committees to have a chairman who is a member of the parent committee. During most of the period under review four Nobel Prize Winners have been amongst the scientists who have served on this committee. The Physical and Biological Secretaries of the Royal Society and the Chairman of the University Grants Committee (U.G.C.) also sit with the R.G.C. as Assessors. (The membership during 1956–60 is listed in Appendix B 2 (iii), page 148.)

APPOINTMENT OF SUB-COMMITTEES

5. Before 1958 the R.G.C. had only one standing sub-committee, namely that for nuclear physics, which at that time still accounted for about half the committee's expenditure. However, the work of the Committee became so heavy and varied that a number of sub-committees were appointed in October 1958 to cover the main branches of science and technology within the Department's province. The present sub-committees are for astronomy, biology, chemistry, geology and geophysics, low temperature and solid state physics, mathematics, nuclear physics, physics (appointed after the others to cover those parts of physics outside the scope of the Nuclear Physics Sub-committee and the Low Temperature and Solid State Sub-committee), and technology. The memberships up to December, 1960, are given in Appendix B 2 (iii), page 148.

RESPONSIBILITIES OF THE SUB-COMMITTEES

6. As well as advising on individual applications for grants the sub-committees are responsible for surveying the field of research with which they are concerned. This is a continuing process, but in 1960 D.S.I.R. and other scientific organizations were specially asked by the Advisory Council on Scientific Policy (A.C.S.P.) to give their views on the balance of research effort in the country, and the R.G.C. and its sub-committees were mainly responsible for formulating the Department's views on the balance of fundamental research in universities and similar institutions. (The committee's views are referred to in detail in Section II, paragraphs 3–10, pages 58–61).

7. In awarding its grants to aid university researches D.S.I.R. makes use of the expert knowledge of university scientists to assess the merit of applications. But they also bring personal knowledge of their fellow scientists which is as valuable when assessing the qualities such as scientific imagination on which success in research depends, for it is the men with ideas and with the ability to pursue and develop them who are most worthy of support. This personal knowledge of the scientists which the members of the Committee and

Sub-committees bring to D.S.I.R. is supplemented by the personal contacts which the officers of D.S.I.R. seek to establish by visiting universities. Thereby the Grants Division of D.S.I.R. obtains a knowledge of the circumstances and an understanding of the conditions of those who are seeking, or have been awarded grants. It is the view of D.S.I.R. that this appreciation of the nature and circumstances of research in universities is essential for the successful administration of a flexible and growing scheme of help for research.

PLANNING FOR THE FUTURE

8. One of the first tasks of the R.G.C. after being set up in 1956 was to plan its activities for the five years 1959–64. The main factor in shaping the Committee's plans was the conviction that in the past the research capacity of the departments of science and engineering at universities had not been fully realised, and that further encouragement to university scientists to embark on new and promising researches would benefit both the universities and the nation. The Government's policy of expanding the teaching of science and technology at universities would require a corresponding expansion in research if a sound balance between research and teaching was to be maintained. There was, however, very little information about the amount of effort which university staff were in fact devoting to research. Using the results of a D.S.I.R. survey the A.C.S.P. in its Report for 1956–57 (Cmnd. 278, H.M.S.O. 1957) surveyed the country's expenditure on scientific and technological research according to the source of funds and also according to the sector (industry, Government, university, and so forth) in which the research was carried out. The A.C.S.P. concluded that although the number of scientists in universities was a reasonable proportion of the number available in the country as a whole, nevertheless more effective use could be made of their enthusiasm and high ability by increasing substantially the number of supporting staff in university laboratories. On reviewing the position in its next report, for 1957–58 (Cmnd. 597, H.M.S.O. 1958), the A.C.S.P. added that the provision of certain kinds of equipment as well as the employment of more technicians would enable scientific research workers in universities to do more effective work.

9. D.S.I.R. is only one of the bodies concerned with the support and development in universities and colleges, but its existing scheme of grants seemed well fitted for expansion to meet the needs of the new situation. From its knowledge of University Research Departments, the Research Grants Committee was firmly of the opinion that the academic staff of Universities would be quick to make full use of additional resources which D.S.I.R. might be able to offer them for developing researches in their departments " of special timeliness and promise ". The increase in the number of good applications for the support of such projects which have been received by the Department since it became known that these increased resources are available, has amply confirmed the Committee's view.

THE RÔLE OF THE RESEARCH COUNCILS

10. The rise in expenditure by D.S.I.R. on research in universities towards the end of the five-year period 1954–59, and the possibility that in the following five years the expenditure would rise even higher, gave point to the enquiries initiated by the A.C.S.P. into the respective functions of the U.G.C., the Research Councils (D.S.I.R., the Agricultural Research Council, the Medical Research Council and the Nature Conservancy) and the Royal Society in

providing funds for scientific research in universities. Approximately 70 per cent of the universities' income is derived from Parliamentary grants, of which by far the greater part consists of annual recurrent block grants (not earmarked for particular purposes) made by the U.G.C. Nevertheless, discussions which were held under the auspices of the U.G.C. and reported in "University Development 1952–57" (Cmnd. 534, H.M.S.O. 1958) and in the Report of the D.S.I.R. Research Council for 1958 (Cmnd. 739, H.M.S.O.), concluded that it was desirable that the Research Councils should continue to supplement these grants by special grants for scientific research.

11. On previous occasions the U.G.C. had considered its position in relation to scientific research in universities and had taken the view that teaching and research in universities are not conflicting activities but are complementary, and that the two are so intermingled as to make irrelevant any discussion of their relative importance.

12. The U.G.C. Report for 1952–57 stressed the autonomy which the universities possess and which the Committee is at pains to preserve. Nevertheless, the Committee did point out that its neutral attitude in this respect could give rise to a danger, namely that a university or a particular department which felt a strong urge to devote more effort to research might be obliged to obtain additional funds from a source with special interests, thus surrendering some of the autonomy which the U.G.C. had endeavoured to preserve. In specific terms, the possible danger the Committee had in mind was that an undue proportion of the universities' research effort might be devoted to contract work chosen and sponsored by Government establishments, industry and other sources. However, the Committee assured itself that so far this had not happened but that it required watching. It considered that the existence of alternative sources of funds such as the grants available from Research Councils for projects chosen by academic investigators themselves, was a safeguard.

13. Furthermore, in reviewing the relations between D.S.I.R. and the U.G.C. the latter accepted that it was right and proper that when university scientists wished to develop their researches along new lines they should not necessarily be limited by the quinquennial and other general funds available from the university. If they were, then newly emerging subjects might fail to receive timely support through having to compete for funds with well-established university activities, and the development of research under the stimulus of an exceptional man might not receive adequate financial support if it made disproportionate demands on a university's budget. Though this situation could be met if the U.G.C. were to make grants earmarked for the support of specific new research projects, it did not in fact wish to depart from its traditional policy for reasons set out at length in the U.G.C. Report for 1952–57, and with which the A.C.S.P. was in full agreement (A.C.S.P. Report for 1957–58).

14. Although the Research Councils are bodies through which alternative sources of public funds could be channelled and earmarked for the support of specific scientific researches in universities in a way that met the difficulties of the U.G.C., two problems remained. Firstly, the existence of separate Research Councils involved a risk that support for borderline subjects lying across the main scientific disciplines might be neglected or, less seriously, duplicated. Secondly, researches inaugurated with money from the Research Councils might fail later to find support from the general funds of universities and colleges

unless special arrangements were made to encourage this and to ease the transfer of financial responsibility. The U.G.C. considered that so far as universities were concerned both problems could be settled by discussions between the universities, the U.G.C. and the Research Council. (A further reference will be made to both questions later in the Chapter; see Section IV, paragraphs 1–8, p. 66).

15. The A.C.S.P. accepted the views put forward by the U.G.C. that the Research Councils should continue to play this rôle, and it considered that the advantage of such alternative sources of support outweighed any administrative risks they might entail. It considered therefore that provided further consideration was given to the two problems referred to by the U.G.C., the existing system of multiple sources of support was a satisfactory method of ensuring that research workers with promising ideas were able to develop their researches and that the best use was made of university staff and facilities. In referring to multiple sources of support the Council stressed the value of the financial support given to free research by the charitable foundations and by industry, not only because they increased the total sum spent on university research but also because as alternative sources of support they reduced the chances that entirely novel ventures might go unsupported because of their very unorthodoxy.

16. These deliberations of the A.C.S.P. and the U.G.C. have been mentioned at some length because of their immediate relevance to D.S.I.R. policy regarding grants for research. D.S.I.R. therefore has found in these deliberations encouragement in the substantial development of its existing scheme of grants for researches of timeliness and promise.

RESEARCH IN COLLEGES OF ADVANCED TECHNOLOGY AND ELSEWHERE

17. The Research Grants scheme is not of course confined to the support of research in universities. In practice some 95 per cent of the Department's research grants are made in response to applications from university scientists, but similar problems exist in the support of research in colleges of advanced technology (C.A.Ts.), and other technical colleges and institutions of higher education whose general funds come through the Ministry of Education and the local education authorities. Indeed a consideration which influenced the R.G.C. in planning for an increase in expenditure on grants in 1959–64 was the desire to increase the good basic and applied research carried out in C.A.Ts. and other technical colleges. The Committee feels that here also there is a large reserve of research potential, and that the expenditure of comparatively modest sums could help scientists in these laboratories to make fuller use of their own abilities and of the excellent facilities provided by the Colleges, particularly those which are being rehoused or expanded. Their teaching of science and technology could not fail also to benefit from this.

SECTION II: DISTRIBUTION OF RESEARCH EFFORT

BALANCE BETWEEN BRANCHES OF SCIENCE AND BETWEEN UNIVERSITIES

1. The Research Grants Committee had been aware that, when the funds available to D.S.I.R. were restricted during the economically difficult periods that followed World War II, there was a tendency for the comparatively few

grants which were being awarded to be concentrated in the larger and better-known research schools. This was to be expected partly because, other things being equal, larger schools were statistically more likely to produce good men and ideas, and partly because the most promising scientists would tend to be attracted to the well-known schools. However, the Committee feels that too great a concentration of effort in a small number of research centres, and too much expenditure on popular lines of research, would impair the scientific health of the country. It does not pretend that the avoidance of this risk lies entirely in its hands but, since it cannot fail to exercise some influence on the growth of science, it can make a contribution towards maintaining or improving the balance. The right balance of effort in such imponderable matters is not easy to define, nor is it easy to assess what influence each factor exerts. The Committee's general aim is therefore to help the growth of potentially valuable branches of science and technology which appear to be less flourishing and to help those universities and colleges—often the smaller ones—where research is being carried out by keen but small teams which, without more support, may cease to be viable; in addition it gives its help to the well-established subjects and famous laboratories.

2. Two branches of science which during the period under review the R.G.C. has regarded as being especially in need of increased support are biology and technology. Biology is in a special position: in that parts of it fall within the scope of each of the four Research Councils, a fact which at first sight makes it appear well provided for. Although the R.G.C. has satisfied itself that there are no major branches of biology not covered by one or other of the Research Councils, it has felt that the more fundamental aspects of biology, through being the concern of all the Research Councils, might run the risk of being the responsibility of none. The Committee therefore felt it could play a useful part in ensuring that promising projects which are not of immediate interest to any of the more specialized Research Councils do not become neglected on that account.

3. The comparative neglect of basic research in technology in this country has been a matter for concern for many years. The reasons for this neglect and perhaps some of the possible remedies, lie outside the scope of this report, but reference to one aspect of it has already been made in paragraph 21 of the chapter dealing with D.S.I.R. Research Studentships (Chapter 2, Section III) and to other aspects in Chapter 3, Section II in paragraphs 8–15. An aspect which directly concerns the R.G.C. is the feeling which until recently has seemed to exist in engineering circles in universities and colleges that D.S.I.R. research grants are primarily for the basic sciences, rather than for technology. This belief seemed to be confirmed by the fact that membership of the Committee which advises D.S.I.R. on the award of research grants has been weighted in favour of the pure sciences. The R.G.C. therefore let it be known that, far from underestimating the desirable place of technology in universities and colleges it was aware of the present comparative neglect, and in this respect was most anxious to encourage a higher level of technological research. To offset the criticism that the Committee was biased in membership towards the pure sciences it appointed a sub-committee under the chairmanship of one of its members, Sir Willis Jackson, to give special attention to research in the field of technology, and the effects of this innovation have been encouraging.

BALANCE OF RESEARCH EFFORT IN PURE SCIENCE

4. In 1960 the Advisory Council on Scientific Policy (A.C.S.P.), as the result of a request from the Minister for Science, asked D.S.I.R. to give its views on the balance of research effort in science and technology in this country. The R.G.C. in considering this balance in universities and similar institutions, came to the conclusion that research effort is reasonably adequate in the main and traditionally recognized areas of the chief scientific disciplines, such as physics, chemistry and biology. In these main areas were the largest number of undergraduate students, and substantial numbers of teachers most of whom were able to devote at least some time to research. The research in these areas could however be developed flexibly and maintained at an adequate level only if substantial and increasing resources for research supplemented within U.G.C. quinquennia by adequate grants from D.S.I.R. were made available from the general funds of the universities, in order to maintain a staff-to-student ratio well in excess of pure teaching requirements.

5. However, the R.G.C., advised by its sub-committees, did note a number of special subjects, mainly newer and borderline ones referred to below, in which it considered the present effort inadequate. The Committee considered that there is insufficient effort in the fringe areas between these main fields, for example in biophysics, geophysics, meteorology and oceanography. Relatively few graduate students take up research in these subjects. Moreover partly because there is little undergraduate work either, there are few teachers and often small encouragement to set up research schools. The R.G.C. appreciated that it would take time to change this situation, but by deliberate encouragement of research, beginning if necessary on a more generous scale than is needed in the better established subjects, it considered that research groups could be built up which would attract more students and result in more trained men. The key to the development of these special research groups lies in giving full support to the special interests of men of outstanding ability and originality of thought, and in fostering the interest and co-operation of the universities. The Committee considered however that if the most effective help is to be given in developing research in these borderline areas it is essential that, in addition to any help from normal D.S.I.R. grants, special means should be found to provide facilities where these are lacking and cannot readily be obtained through normal university sources.

6. With regard to the distribution of additional support the Committee believed that, with limited numbers of scientists trained in these borderline subjects, research would best be concentrated in a few centres. Attempts to set up groups too small to be viable might have to be discouraged, although limited competition between a few groups would stimulate healthy growth.

7. In the main fields of pure science covered by D.S.I.R. the following are areas which the Committee considered require attention:

(i) *Astronomy*

In the main, theoretical astronomy has been studied in this country by very small groups which have tended to be handicapped by their fragmentation. The Committee felt that a need may exist for a national institute of theoretical astronomy. On the practical side the visual astronomy of the Southern Hemisphere appeared to be underdeveloped, and possible means of supporting this are being examined.

(ii) Biology

A number of subjects within the field of biology require further effort, for example genetics, microbiology and biological engineering, which touches on very different fields.

(iii) Chemistry

In the field of chemistry the rapid expansion of the teaching side of universities may be tending to restrict the amount of effort devoted to research. Two branches of chemistry recognized as requiring further development are electro-chemistry and the properties of the amorphous state, particularly polymers, rubber and glass.

(iv) Geology

A considerable number of topics were considered to be in need of development. These include work on the physical-chemical relations of minerals and rocks, seismology, new analytical techniques for geochemistry, age determination in relation to geological problems, and marine geology.

(v) Physics

The Committee considered that the following branches of physics were being neglected: high temperature physics, the study of neutrons in the solid state and the study of ultra-violet and soft X-ray spectroscopy.

BALANCE OF RESEARCH EFFORT IN APPLIED SCIENCE AND TECHNOLOGY

8. A balance of research effort in applied science is desirable in the national interest. To determine the right balance it is necessary to look ahead and try to predict in what fields further knowledge will most likely be useful in solving the economic, industrial and social problems of the next few decades or more. Some of those most obvious to the Committee were energy generation and distribution, the basic properties and economic use of materials and other resources, textile machinery, plastics engineering, fracture mechanics, vibration engineering, low temperature engineering and the extraction and refining of metals, the development of automatic control of machines and other applications of electronic computers, the economic development of various forms of transport, the control of noise, and problems of the relationships of men to machines and to one another in industry. The Committee appreciated that these problems required the combined attention of industry and Government as well as the efforts of universities and colleges. A broad approach was necessary to determine priorities and the allocation of different aspects of the work to the centre best equipped to solve them.

ORGANIZATIONAL PROBLEMS IN TECHNOLOGICAL RESEARCH

9. The Committee considered that one of the outstanding problems is an organizational one, namely the need to overcome a tendency to place technological research in compartments, not only in universities and colleges but also in industry. For rapid progress to be made in some fields of research such as fuel technology and engineering materials, a narrow attack within conventional departmental boundaries is no longer sufficient: what is needed is for research teams containing experts in different branches of science and technology to be set up so that the problems can be studied more deeply and broadly.

10. The Committee believes that universities and colleges of advanced technology have an important contribution to make in advancing the country's technology, especially through fundamental technological research and the training of research workers with the right attitude to present-day technology. Great effort on a broad front will be needed to achieve a satisfactory state of affairs in this field, in universities in science and technology, and in national and industrial laboratories in application and development. Good collaboration is also necessary between these groups. But if technological work is to achieve its maximum effect there must be more voluntary co-operation between and within universities for broader and deeper study of promising fields, in ways that may cut across present departmental and faculty boundaries. Three important fields in which for a start the Committee felt such co-ordinated studies are likely to be especially valuable are studies of the basic properties of materials, the mechanics of metal forming, and automatic control.

LINKS WITH NATIONAL AND INDUSTRIAL LABORATORIES

11. The R.G.C. was of the opinion that effective communication between university and national and industrial laboratories is essential for the successful prosecution of research, particularly in applied science and technology. At the outset problems must be identified, and later their solutions put into practice; for both tasks, closer links are required between the laboratories concerned. D.S.I.R. is in a favourable position to strengthen such links: a great part of the Government's civil research is carried out in the research establishments of D.S.I.R., and full opportunities are taken to keep D.S.I.R. scientists and university investigators who require D.S.I.R. support in touch with one another. In the same way contact is maintained between the research supported by D.S.I.R. in universities and in research associations.

12. Two recent developments in the Department's policy are designed to improve the two-way communication which must exist between research and industry. In 1959 D.S.I.R. set up a Development Committee to advise it on its policy of providing further support of research and development in industry, and a joint committee was established with the National Research Development Corporation (N.R.D.C.) to examine development problems of common interest to both bodies. A development project which promises a financial return in a reasonable period of time will usually commend itself to industry, though the assistance of the N.R.D.C. may be required in some cases. However, there may be development projects which it is in the nation's interest to pursue but which are not sufficiently attractive commercially in the short term to find support from industry or the N.R.D.C. The Development Committee is concerned with projects of this kind.

13. Another D.S.I.R. activity designed to bring to light the research and development needs of important industries has been a series of detailed surveys (for example those of the machine-tool and ship building and marine engineering industries) carried out under the Economics Committee of D.S.I.R. Although the Economics Committee's report on the machine-tool industry is now well-known, it is worth recalling it in this context to illustrate the way in which D.S.I.R. is seeking to strengthen the two-way link between research and industry. The report drew attention to the need of the industry for increased facilities for research and training. As a consequence D.S.I.R. has allocated greater resources to machine-tool research in its own laboratories and in research

associations (including the setting up of the new Machine Tool Industry Research Association), and in order to develop training as well as research has made grants in support of research groups in universities and colleges. To speed up the return of the benefits of research to the machine-tool industry the Economics Committee recommended the placing of development contracts, and this is being done by the Development Committee. Furthermore, patents arising out of the research now being carried out are being taken over by the N.R.D.C. for exploitation.

14. Stronger links between research and industry could be established by greater interchange of staff between university, industrial and Government laboratories. This could be encouraged for example by the recognition of the latter for advanced study and by their use by universities for projects requiring large-scale equipment and the use of their specialist staff for teaching in universities and technical colleges. D.S.I.R. would welcome greater collaboration of this kind between universities and colleges and its own laboratories to their mutual benefit.

15. Co-operation between universities, industry and Government would assist also the solution of another problem in the applied sciences, namely the "scale" problem. Technological research leads to investigations with models and pilot-scale plant, but eventually investigations on a full scale are required. Such investigations need resources which are often beyond those normally available in a university but which can be provided at a national laboratory or in industry. This should not mean that the national centre should try to carry out the teaching functions of a university, but it may well provide an extension of the universities' research facilities so that the most efficient and economical use could be made of expensive and complex equipment.

SECTION III: LARGE-SCALE RESEARCH FACILITIES

THE PROBLEM

1. The problems relating to large-scale research facilities are encountered in fields other than technology, for example in nuclear physics and in radio-astronomy where the basic requirements for research may involve capital expenditures of hundreds of thousands of pounds on equipment.

2. There is obviously need for careful consideration of how such equipment can be put to the best use, in order to achieve the maximum economy in money, equipment and skilled scientific and technical effort, and to reduce the risk of very large equipment becoming a burden on an institution and distorting its efforts. There are however many factors which need to be taken into consideration, and some of these cannot be assessed in terms of money or other measurable quantities. Each case is different and must be decided on its merits. Such examination requires consideration of some or all of the following questions:

(a) The type of equipment and its cost; the space, staff, and other facilities required for its full utilization; its effect for good or bad on the university, college or research institution.

(b) The ease (or difficulty) and the saving (or cost) of sharing equipment between one or more teams; the effect of sharing on the freedom and rate of progress of research, and its effect on capital and running costs need scientific and administrative knowledge of the circumstances of each case.

(c) The scientific promise of the research proposed; the value of more than one approach using similar equipment in different places.

(d) The potential economic value of the research.

(e) The scientific ability of the research workers involved.

TYPES OF EQUIPMENT

3. It is necessary to recognize that there exists a range of research equipment from the general service type of machine or instrument to special research equipment.

(a) General service equipment, e.g. computers, electron microscopes, ship testing tank, hydraulic press, etc. In this class are instruments or machines offering a general service—primarily intended for carrying out more or less set operations, or a variety of operations, on data or materials. The operations may be very complex, but the equipment can be used in the service of a number of research teams.

(b) Special equipment. Equipment designed to meet the unique requirements of a particular research programme, e.g. the 250-ft radio telescope at Manchester University.

4. Most equipment required for research will lie somewhere between these two extremes, and some will fulfil both functions, for example a nuclear reactor used as a source of radiation and as an instrument for research in reactor technology.

SHARING OF GENERAL SERVICE EQUIPMENT

5. The shared use of general equipment should not be difficult, particularly sharing between the different departments of a university or research establishment, or between nearby universities or establishments. This may indeed bring incidental benefit as well as economy by leading to the useful sharing of techniques and experience in use; it may even lead to profitable scientific collaboration between research teams which would not otherwise have been brought together. It is impossible to set any figure of capital cost at which sharing of equipment may be necessary or desirable, but capital cost is obviously one of the most important factors to be considered. Sharing of equipment will often ensure its full use, and so justify adequate staff for operation and maintenance, which will result in better service, economy in capital cost and running expenses, and obvious potential benefits. On the other hand, there will always be some degree of hindrance when a research worker has to allow for the requirements of other users. The total cost of time, travelling, etc. involved in sharing may be considerable but can usually be reduced by careful planning, the provision of adequate transport or telephone communication, and, above all, a readiness to co-operate.

SHARING OF SPECIAL RESEARCH EQUIPMENT

6. The sharing of special research equipment is more difficult and needs more willingness if co-operation is to be successful and, in the long run, economical. The difficulty is greater when the equipment forms an integrated part of a particular individual's research programme. It may be of first importance that the investigator or his team should have freedom of access to the equipment whenever required and freedom to modify it to meet their needs. For these reasons two or more research programmes may be incompatible on one piece of apparatus. Moreover in the case of the most advanced type of equipment

proposed by a leader in his field there may not be anyone else in a position to make good use of the equipment. Complete control over such apparatus may stimulate an investigator to try out new and sometimes seemingly far-fetched ideas which he would not or could not do if it were regularly required by others or controlled by staff whose aim was to keep it in good running order for its conventionally designed purpose. If equipment is planned to be shared between a number of users its design may reflect the lowest common multiple of all the uses that can be envisaged, and this may sacrifice high performance to general utility. The economy and benefits derived from the operation of equipment by a central group on behalf of research teams may be offset by the risk of overlooking significant anomalies in behaviour which might be valuable pointers to the research man, but merely a nuisance to the skilled technician. Against these disadvantages must be set potential benefits similar to those for general purposes equipment, such as efficient operation, economy in purchase, staffing and operation, and the possible value of enforced collaboration.

7. If equipment is provided for a university or similar institution by means of a D.S.I.R. grant, it may be made a condition of the grant that the equipment must be made available for use by other workers in the field. Similarly, sometimes it is desirable to stipulate that if as a result of changes in staff of a university or other institution a large piece of equipment is not being adequately used, then the institution must be prepared to make it available to workers from other institutions.

NATURE OF THE RESEARCH PROGRAMME

8. The nature of the research, or researches, proposed must also be considered in reaching a decision about sharing. Most important, but most difficult to assess, is the scientific promise of the work proposed, which will depend particularly upon the ability and imagination of the scientist himself. Another factor is the extent to which the programme requires and deserves the greatest freedom to try out new ideas and experimental methods. Again, in entering upon a new field, the value of more than one approach has to be taken into account in deciding whether to restrict support to one team, or to back more than one. Where the work proposed is in, or near to, the field of applied science, the potential economic value of the work must also be assessed. Finally, a factor which is even more difficult to assess is the prestige value of the possession of a large and possibly unique piece of equipment. Although the provision of such equipment purely as a status symbol can never be seriously considered, there is no doubt that obtaining a large and unique instrument can have a great and worthwhile effect on the morale of a research team and be a strong stimulation to greater efforts, as well as a powerful attraction in recruitment. Undoubtedly it can have prestige value for the university or institution and for the nation.

ABILITY OF THE RESEARCH WORKERS

9. However, without doubt the most important factor remains the ability of the scientist who will be chiefly responsible for the work to be done with the equipment under consideration; his scientific imagination; his ability as a team leader; his ability to organize his work to get full value out of the equipment; his ability to persist with his scientific aim, and not to be distracted by the business of obtaining and running a large machine, or by the fascination of the machine itself. All these need to be considered before a large piece of equipment

is entrusted to an investigator. This must be done in the light of a similar assessment of others in the same field. Although it is clearly preferable to give substantial support to one outstanding man rather than to two or three of lesser ability, the choice will in fact often have to rest between two or three of equal standing. Finally if sharing between two or more teams of a single instrument is being considered, it would be foolish not to take into consideration the personalities involved and whether such collaboration will in consequence be effective or not.

ORGANIZATION FOR SHARING

10. If a decision is reached that some form of co-operative use of equipment is desirable, either on grounds of cost or the burden of operating and maintaining the equipment, it will be necessary to consider what form of organization will best meet the circumstances. The sharing of equipment between departments within a university or research establishment should not be difficult and is a matter for internal organization. Slightly more difficult may be the use by one institution of equipment placed in another, but again, experience should show how this can be smoothly carried out provided goodwill exists. For very large machines intended for general use it may be desirable to establish a research laboratory or institution around one major machine, for reasons of siting, convenience, staffing, etc. So far the National Institute for Research in Nuclear Science (N.I.R.N.S.) is the only example of this type of organization in the U.K. It is operated with the aid of Government funds through the Atomic Energy Authority. If further national institutes for research in fields of basic science are contemplated, consideration will be required of their possible connections with universities, C.A.T.s or Government establishments (such as the National Physical Laboratory or the National Engineering Laboratory); and of how their staffing and financing should be organized, whether for example, as Government establishments, units (on the M.R.C. pattern), university institutes, or perhaps on the American pattern of research centres located close to universities and operated by a university or a consortium of universities at Government expense. In deciding what form of organization would best suit any particular instance, it is clearly of first importance to create an atmosphere in which scientific research can flourish and with opportunities for exchange of ideas and of people. Provision must be made also for the free growth of the institution not necessarily in size but also in the direction its researches lead.

INTERNATIONAL COLLABORATION

11. All that has been said so far refers to collaboration between institutions within the U.K. At the same time international collaboration in research programmes and the sharing of research facilities is growing. This is to be welcomed not only for the reasons that apply at home, namely, economy, mutual stimulation of interest, and so forth, but also because of the essentially international basis of some research programmes, e.g. oceanography, meteorology; or because of the special virtue of a particular country or region (for example the Southern Hemisphere for astronomical observation). Though larger resources may become available as a result of international effort, the difficulties for organizing effective collaboration are greater. As experience grows it should become easier to select the instances in which international sharing is likely to be worth considering.

THE FUTURE

12. The foregoing are very live issues at the present stage of development of university research, and they are engaging much attention in the R.G.C. and in wider circles of Government. The problems are being considered in general terms at this stage, the conclusion being that in view of the size, cost and complexity of operation of so much modern scientific equipment, the possibility of collaboration in its use must always be considered and the most suitable type of organization decided on the merits of each case. Whatever decisions are made they will concern a considerable part of the country's research effort, and the next few years will therefore see some important developments in the organization of research.

SECTION IV: SOME RECENT DEVELOPMENTS

LONGER-TERM RENEWABLE GRANTS

1. In 1959, under the names "Longer-Term" or "Renewable" Grants D.S.I.R. introduced a major extension of its arrangements for the support of research at universities. It was then announced that D.S.I.R. would be willing to provide longer-term financial support than hitherto for outstanding university investigators embarking upon lines of research of exceptional promise for which their universities were unable to make adequate provision. Such support may be required to establish expensive new lines of research without distorting the financial framework of the university, especially if the research is one whose qualification for complete assimilation by the university may be slow to establish itself. In cases where it is envisaged at the outset that a longer period may be required to establish the research, potentially renewable D.S.I.R. research grants will be awarded initially for periods of three to eight years, and timed to end with a U.G.C. quinquennium. In general the intention is that work supported in this way will eventually be taken over by the university if the university decides it shall be continued, though of course D.S.I.R. can offer no guarantee that general funds made available through the U.G.C. will be adequate for this purpose.

2. Teams supported with the help of these D.S.I.R. grants may consist of regular staff employed by the university, assisted by temporary university employees paid for but not employed by D.S.I.R. In this respect the research teams differ from "research units" of the type supported for example by the Medical Research Council, the staff of which are employees of the supporting organization.

3. The criteria which favour a project being considered for a longer-term grant are:

- (i) At the outset it should appear probable that for scientific reasons the work should be carried on for longer than the initial period of the grant;
- (ii) the work should be concerned with the development of a project with a clearly defined objective or the exploration of a new field of research, especially under the guidance of an outstanding scientist given freedom to develop the work in his own way, such development or exploration requiring a substantial period to prove its worth;
- (iii) continuing support, in whole or part, would be required for a large-scale project to ensure that the best use would be made of expensive equipment.

4. Certain considerations are likely to lead mistakenly to some applications for these longer-term awards which are not what the Committee had in mind: the purpose of a longer-term grant is not to substitute one omnibus grant for a number of overlapping grants or contracts for reasons of administrative convenience, nor to continue general support, in whole or in part, of an existing programme which should be supported by a university from its general funds.

5. Since the provision of funds for university buildings is in general a U.G.C. responsibility, the university is expected in normal circumstances to provide the accommodation required for a project supported by a longer-term grant, as is customary at present under D.S.I.R. Research Grants. However, if an investigation requires some special or unusual structure or housing unlikely at any time to be useful for any more general purposes, D.S.I.R. is prepared to consider providing this. Similarly, if the accommodation or equipment requires technical maintenance of a sort or on a scale not normally provided by a university, D.S.I.R. will consider providing this also.

6. When the Department awards longer-term grants there is an understanding that, towards the end of each U.G.C. quinquennium and, in consultation with the university, D.S.I.R. will consider whether, in the light of its scientific progress and of its cost, the work so supported should be continued and, if so, whether the full cost should fall on D.S.I.R., or should be shared between D.S.I.R. and the university, or should be assimilated in future by the university into its established work and supported from its general funds. Considerations which affect such a decision include:

(i) whether the work has become sufficiently well established to form an integral part of the university's work;

(ii) whether other universities have decided that scientifically similar and otherwise comparable work is suitable for support from general unversity funds;

(iii) whether the magnitude or unpredictability of the cost would unduly disturb the university's finances;

(iv) whether the cost in relation to the importance and promise of the new line of research is such that D.S.I.R. and the university, either separately or jointly, could not justify continuing support for the project.

7. A few grants of this kind have now been made by D.S.I.R. In most instances they have been offered for an initial period ending in 1962, so that their first review for possible renewal could be synchronized with the universities' estimates of U.G.C. funds for the quinquennium 1962–67. Researches which have been supported since 1959 by these potentially renewable grants, and which turn out to be genuinely long-term researches, cannot be expected to have become demonstrably established by 1962 and ready to be taken over by the university concerned. Nevertheless D.S.I.R. did not wish to delay the launching of the new arrangements for the assimilation of responsibility by the universities, and discussions between D.S.I.R. and the universities have taken place on the financial future of a number of projects.

8. The longer-term renewable grant is not to be thought of as a separate kind of grant which in anything but duration is different from the normal type of D.S.I.R. grant; it introduces a new flexibility into the scheme, as now in some instances D.S.I.R. grants may be renewed.

NATIONALITY OF APPLICANTS

9. Before 1957 D.S.I.R. would consider applications for research grants only from British subjects normally resident in Great Britain, but in that year eligibility was extended to British subjects normally resident in Northern Ireland, so that all British staff of universities and colleges in Great Britain and Northern Ireland were eligible to apply for grants. By a further amendment to the regulations in 1960 the grants were also made available, subject to Research Council confirmation in each case, to members of British university permanent staff of foreign nationality.

SENIOR VISITING FELLOWSHIPS

10. Under the research grants scheme arrangements to enable investigators to pay for Senior Visiting Fellowships were introduced in 1957. These Fellowships help investigators to obtain advice and high level assistance in connection with their own promising researches by inviting senior scientists of distinction from other research schools in this country or abroad to be attached to the applicant's university or college for periods of up to a year. Since the Fellowships form part of the D.S.I.R. Research Grants scheme, applications must come from investigators in this country who wish to obtain assistance for a promising research by means of D.S.I.R. research grant; they cannot be accepted from foreign scientists who wish to visit this country primarily for the benefit of their own research. These Fellowships were first introduced to meet a need felt at the time mostly by mathematicians and theoretical scientists, although they are available in other subjects as well.

O.E.E.C. (NOW O.E.C.D.) SENIOR VISITING FELLOWSHIPS

11. Since 1959 D.S.I.R. has been a national centre for the consideration of applications for Senior Visiting Fellowships awarded on behalf of the Organization of European Economic Co-operation (O.E.E.C., which has been known as O.E.C.D., the Organization for Economic Co-operation and Development, since the autumn of 1961). The scheme is intended to help scientific and technological institutions in member countries to keep abreast of new techniques and developments in science.

12. An allocation of about £7700 p.a. is available for awards in science and technology, including agricultural science but excluding medical and social sciences. Under the scheme scientific and technological institutions in the United Kingdom may send senior scientists and engineers on their staffs to study for short periods at similar institutions in other member countries or, in special cases, in countries outside Europe and North America, or they may invite specialists from abroad to give advice on particular aspects of the sponsoring institution's work. The Fellowships do not provide for salaries but cover travelling and subsistence charges.

SPACE RESEARCH GRANTS

13. The United Kingdom Space Research Programme started in 1955 mainly with rocket work in the upper atmosphere. It received a big impetus in 1959 with plans for the instrumentation of satellites and with the announcement of initial Government support. The programme now provides for a combination of work under the general supervision of the Minister for Science, carried out by research workers at universities and in Government departments, and coordinated through the British National Committee on Space Research (B.N.C.S.R.) of the Royal Society.

14. So far the main effort in the programme has been concentrated on the design of experiments and the development of the related instruments and equipment for use in sounding rockets and artificial earth satellites. This work in universities is helped by Government grants paid through D.S.I.R. on the recommendation of the B.N.C.S.R. Twenty-four projects to the value of £297 543 at ten universities had been approved up to 30th September, 1960. The work is at present concerned largely with the production of apparatus for use in Skylark sounding rockets and in American-launched "Scout" satellites. The programme also includes some theoretical scientific studies and satellite tracking.

SOUNDING ROCKET PROGRAMME

15. For several years past the Minister of Aviation has made available for civil research purposes a number of "Skylark" vertical sounding rockets, which are launched from Woomera in Australia. In addition payload space in other research rockets has been made available when possible. Opportunities have in this way been offered to university and Government research workers wishing to undertake experimental work in the upper atmosphere or to test instruments and equipment being developed for use in satellites. Since 1959 twenty successful "Skylark" launchings have taken place in this programme, and important experiments from the Universities of Belfast, Birmingham, London and Wales have been carried out.

RESEARCH WITH SATELLITES

16. Arrangements were made with the United States Government in 1959 whereby the United States National Aeronautics and Space Administration (N.A.S.A.) would launch, within a few years, three earth satellites containing instruments provided by the United Kingdom. The choice of experimental work is decided on proposals submitted by research workers in universities and Government establishments and grants are made through D.S.I.R. to the former. The preparation of the payloads for these satellites, which will be launched by means of the "Scout" rocket system, is supervised by joint working groups representing the N.A.S.A. and the B.N.C.S.R. The first U.S.A./U.K. satellite was successfully launched in April 1962. This included apparatus for probe studies of ions and electrons (University College, London) and studies of electron density (University of Birmingham), cosmic ray studies (Imperial College, London), and solar radiation (University College, London). The selection of experiments for the second payload has recently been finalized and it is planned to measure galactic noise and explore the upper ionosphere (Cavendish Laboratory, Cambridge), measure atmospheric ozone by two methods (Meteorological Office), and also to determine the micro meteorite flux (University of Manchester).

SECTION V: ADMINISTRATIVE AND FINANCIAL ARRANGEMENTS

DEALING WITH APPLICATIONS

1. An application for a D.S.I.R. research grant will be accepted at any time of the year, though there have to be closing dates before each R.G.C. meeting. The application must be submitted by the investigator who will be responsible for the project, and it must have the formal approval of his institution. With

two classes of exception, each application is considered by one or more of the specialist sub-committees of the R.G.C. Applications in the human sciences are considered by the Human Sciences Committee (H.S.C.); and applications for space research grants are made to the Royal Society and are considered by the British National Committee on Space Research (B.N.C.S.R.). The sub-committees of the R.G.C. normally meet three times a year, and a closing date for applications is set for each group of meetings, namely 1st February, 1st May and 1st November. So that the time taken to deal with straightforward cases may be reduced to a minimum the sub-committees themselves have authority from the Research Council to recommend the award of the smaller grants without reference to the main Committee. Larger grants require the endorsement of the Committee; and still larger grants are referred to the Research Council. Frequently sub-committees may not reach a decision on the merits of an application until they have obtained written comments from expert referees. Occasionally they may ask a referee and the applicant himself to discuss the application with them, especially in the case of large applications for which *ad hoc* panels are invariably set up to interview the applicant and often to see his work and discuss it with him. The time taken to deal with the smaller, simpler applications is about six weeks; the average time for dealing with other grants, except the very largest, is four months.

REGULATIONS FOR GRANTS

2. Almost all D.S.I.R. research grants are for the support of research in universities and colleges, and the regulations governing the grants are therefore, mainly designed to meet the conditions of these institutions. For example, an application must be submitted with the approval of the university which must be prepared to provide the normal basic facilities for the research. The grants are made to the university and not to the individual investigator, the institution accepting responsibility for administering the grant.

3. A statement of the purpose of the grants and the regulations governing them, are published annually in "D.S.I.R. Research Grants" (published for the Department by H.M.S.O.). Complimentary supplies of this publication are circulated to universities and colleges and attention is drawn annually to changes in the regulations. Applicants are invited to consult D.S.I.R. about the ways in which the grants can be used, and so settle any questions of doubt before a formal application is submitted. Members of the Department's staff visit the universities periodically to discuss generally the operation of the scheme of grants and to help clear up specific problems.

ADMINISTERING THE GRANTS

4. When a grant is recommended as a result of an investigator's application, a formal offer of grant, outlining certain conditions, is made to the investigators' parent institution. If the offer and the conditions are accepted the grant is paid in quarterly instalments in reimbursement of expenditure incurred during the previous quarter by the institution. The grant is available over a specified period of time to meet commitments incurred during that period. The conditions governing the grant are designed to allow the investigator to proceed freely with his researches provided that his programme remains substantially the same as that proposed in his application. Thus, as a general rule, once the grant is announced the institution does not have to seek the prior approval of D.S.I.R.

before incurring particular items of expenditure, unless this would cause the grant, or a limited part of the grant, to be overspent. D.S.I.R. may however disallow claims for the reimbursement of expenditure if it considers the expenditure is not a proper charge under its conditions and regulations.

5. The conditions governing the grants also require that economy should be exercised in administering them; for example, competitive tendering should be used when appropriate. For very large grants additional controls are introduced, the most important being that the institutions are required to set up management committees to administer large capital grants. This procedure follows that recommended in the Report of the Committee under the Chairmanship of Sir George Gater on the Control of Expenditure by the Universities from non-recurrent grants (H.M.S.O., 1956).

ALLOCATION OF FUNDS

6. It is one of the responsibilities of the R.G.C. to advise the Research Council on the sum it should include for research grants in the Department's Estimates. This is determined by the expenditure which is expected to arise from grants which are still current from previous years, and by the expected requirement for new grants. Estimating the financial provision for new grants is difficult because of the steep rise in the number of applications which has occurred since 1956, and in particular because of the considerable numbers of applications for very large grants (£100 000 and over). The latter grants account for roughly 50 per cent of D.S.I.R.'s annual expenditure on research grants. Since the cost of all research grants, whatever their size, has to be met from a single fund, the Committee's policy in regard to funds for new grants is to give priority to smaller grants for which the demand is heavy, and through which, because of the number of individual research workers they involve, the greatest amount of encouragement of research in universities can be given.

GROWTH OF THE DEMAND

7. Between the wars and until 1955 the number of grants awarded annually never exceeded 50. In the academic session 1955–56 only 36 applications for grants were received; the following session the number rose to 149. The following table shows the number and value of applications received and the number and value of awards made in each of the academic sessions 1956–57 to 1959–60 (including the natural sciences and technology, but excluding space research and the human sciences).

Applications Received and Grants Awarded in Science and Technology, 1956–57 to 1959–60

Academic Session (Oct–Sept)	Applications received		Grants awarded	
	Number	Value £	Number	Value £
1956–57	149	1 422 000	115	824 000
1957–58	177	1 334 140	147	1 040 000
1958–59	366	3 246 000	281	2 103 000
1959–60	392	4 201 303	321	2 142 000

8. Since the grants vary in duration and are paid quarterly in arrear on the receipt of accounts for the research, the Department's annual expenditure differs from the value of awards made annually, and during periods of expansion actual annual expenditure lags by a year or two behind the annual value of new awards. The following table gives the Department's annual expenditure on research grants since 1st April, 1956.

Financial Year (1st April–31st March)	*Expenditure on Research Grants** £
1956–57	360 354
1957–58	476 500
1958–59	445 650
1959–60	876 578
1960–61	1 433 309

* Excluding Human Sciences and Space Research.

SECTION VI: REVIEW OF RESEARCH RESULTS

INTRODUCTION AND ACKNOWLEDGEMENT

The value of a report on D.S.I.R. research grants can be increased by an account of their effects on research in this country, and of some of the work which is being carried out.

Over 800 grants were awarded between 1956 and 1960, of which about 95 per cent were for work in universities and most of the remainder for work in colleges of advanced technology and technical colleges. The distribution of grants by institutions and by branches of science is shown in Appendix D, pages 188–190.

It is estimated that in 1959 D.S.I.R. grants constituted between 5 and 10 per cent of the universities' expenditure on research. This may seem a small part of the universities' research expenditure but it is a significant part as its influence on the development of research is much greater, for the Department's policy is to use its grants chiefly for aiding the initiating of new researches of "special timeliness and promise". It is not, however, of such a magnitude as to give rise to fears of interference in the traditional academic freedom in research.

As can be seen from Appendix D 1, p. 185, D.S.I.R. has increased its support in most branches of science since 1956. By and large this has reflected the universities' own pattern of research growth rather than a planned selective development of science by D.S.I.R. It was decided to concentrate in the first instance on a general stimulation of the most promising men and ideas in research, to provide greater freedom of resources and in this way to increase the momentum of research. It was felt that when this had been achieved, then would be the time to look more closely at the general pattern of research as it had built up.

By proceeding in this way the Research Grants Committee (R.G.C.) has undoubtedly been able to provide a more effective impetus to research than if its aid had been given according to a fixed plan. The Committee has also been able to form a better estimate than it could otherwise have done of the extent to which the research potential of the universities was under-used for lack of resources and also of the kinds of assistance that are required, and the variations in requirements of the different fields of science. For example chemists, in particular, and to a smaller extent biologists and geologists, are needing research equipment which would exploit the use of new techniques; mathematicians seem chiefly to require funds for travelling, both for visits abroad and for visits by foreign experts to this country; nuclear physicists, as well as requiring their own expensive accelerating machines and ancillary equipment, are needing help in using the very large accelerators at C.E.R.N. and other laboratories abroad.

Of over 800 grants awarded in 1956–60 well over half were still current at the end of 1960; it is too soon to assess the results of the research carried out with the aid of the grants which have so recently terminated. Since moreover only a few of the grants can be referred to individually in the compass of this report, a selection has been made to show something of the variety and scope of the work covered by them. Topics for review have been selected also from the point of view of their general interest. In order to put some researches in their correct perspective, it has sometimes been necessary to refer also to work which other bodies have supported.

Special mention is made of the Department's financial support for nuclear physics research because from 1946 special help has been given to enable universities to catch up with the rapid advances made, mainly in Government laboratories, during the war, and no comprehensive account of this has previously been issued.

D.S.I.R. is indebted to chairmen and members of the R.G.C. sub-committees and to a number of investigators for the help they have given in the preparation of the following contributions.

ASTRONOMY

Number and Value of Grants Awarded

1956/57 (Oct–Sept)		1957/58 (Oct–Sept)		1958/59 (Oct–Sept)		1959/60 (Oct–Sept)	
No.	Value	No.	Value	No.	Value	No.	Value
4	£44 130	6	£33 575	7	£233 400	10	£98 678

Four topics, two in optical astronomy and two in radio astromony, have been selected to illustrate the Department's support of research in astronomy during the past four years.

In optical astronomy the work supported at Cambridge University and described below is largely concerned with developing new apparatus and techniques. At the Radcliffe Observatory, Pretoria, work is being carried out on the calibration of one of the important steps in determining the distance of stars, namely that involving the use of the Cepheid variable stars. The Observatory is especially well favoured for this problem since the Cepheids of the Magellanic Clouds, which are the nearest galaxies to our own, can be observed from its site in the Southern Hemisphere.

In radio astronomy the work of Cambridge University and Manchester University has been supported by a number of grants during the period. At Cambridge there has been a concentration on the problem of counting sources of radio emission, and the work has reached an advanced stage at which the results may be of great significance to cosmology. At Manchester University a considerable effort is being devoted to determining the distances of observed radio sources, for which no simple method exists. This work is also of importance in testing cosmological theories.

Optical Astronomy at the Cambridge Observatories

With the help of a D.S.I.R. grant, Professor R. O. Redman has built and operated at the Cambridge Observatories a solar magnetograph of the Babcock type. Field strengths down to about 1 gauss can be measured accurately. Measurement near the poles of the sun show a weak and rather irregular field of the order of 1 gauss and confirm Babcock's polarity, which is the reverse of that of the preceding solar cycle. The field reversal and the marked day-to-day irregularities give strong evidence that what is measured is not the outer part of a general magnetic field permeating the whole body of the sun, as was thought until recently, but something much more superficial. This work is continuing.

The purchase of a Zeiss measuring machine has assisted an investigation, still in progress, into the possibilities of astrometry with Schmidt telescopes. This has shown that positional errors are about the same as those from conventional astrographs of twice the focal length. This problem has also involved investigation of emulsion shifts in photographic emulsions, which are found to be significantly reduced by the use of thin emulsions and "tropical" processing. This work is making a considerable contribution towards overcoming the drawbacks of field distortion which have prevented the Schmidt telescope from being used for metrical purposes.

The purchase of improved electronic equipment has aided researches with the 36-inch telescope, based on the direct photoelectric measurement of bands or lines in stellar spectra, using new techniques with photomultipliers involving pulse-counting (a method often described as photon counting). The method is sensitive and fast. Line-strengths and band-strengths have been studied as functions of spectral type, intrinsic stellar luminosity, membership of stellar populations, etc. Many measurements have also been made of the unidentified band (of radiation or absorption) of wavelength 4430Å due to interstellar matter, the nature of which is being studied.

The Radcliffe Observatory

It is natural that the astronomer should be interested in comparing the stars and clusters of stars in other galaxies with those in our own. Therefore it is unfortunate that, whereas the largest existing optical telescopes are in the Northern Hemisphere, the Magellanic Clouds, which are much the nearest galaxies to ours, are visible only to observers in the Southern Hemisphere. A 24-inch telescope, suitably placed, can photograph stars in the Magellanic Clouds which are as faint intrinsically as stars in the Andromeda nebula, which are on the threshold of the Palomar 200-inch telescope. Even for the study of objects in our galaxy the astronomer in the Southern Hemisphere is in a more favourable position, since the centre of the galaxy is too far south to be observed easily from northern latitudes.

Under a Southern Hemisphere project sponsored by the Astronomer Royal and financed by D.S.I.R., Dr. A. R. Sandage of the Mount Wilson and Palomar Observatories and Dr. O. J. Eggen and Mr. J. B. Alexander of the Royal Greenwich Observatory have each gone at various times to the Radcliffe and the Cape Observatories in South Africa in order to secure observations of southern objects.

The work carried out so far under this scheme has been concerned mainly with the broad-band photometry of variable stars and of star-clusters both in the Magellanic Clouds and in our galaxy. A combination of photo-electric and photographic techniques is being employed. At present, a team at the Royal Observatory, Herstmonceux, is engaged in the lengthy process of the measurement of the photographic plates which have been taken with the telescope in South Africa.

In a region of the Large Magellanic Cloud considerable progress has been made towards the derivation of a period-luminosity relation for Cepheids, variable stars of high intrinsic luminosity which can be observed in quite distant galaxies. Since our knowledge of the distance-scale of the universe depends to a large extent upon the use of Cepheids, the question of the zero-point and slope of the period-luminosity relationship is of the utmost importance.

One of the main topics of current interest in astrophysics is the problem of stellar evolution. Much of our information on this subject has been obtained through a study of the colour-magnitude diagrams of star-clusters. In the Magellanic Clouds only stars which are intrinsically quite bright can be observed with existing equipment, and even then in most cases the observations are difficult to make. However, any apparent fundamental differences between the colour-magnitude diagrams of the clusters in the Magellanic Clouds and in our galaxy are of great interest. So far, the colour-magnitude diagrams of four clusters in the Large Magellanic Cloud have been derived and published by astronomers working with the D.S.I.R. aid. In addition a comprehensive three-colour study of the nearby globular cluster NGC 6397 in our galaxy is nearing completion.

Radio Astronomy at Cambridge University

At Cambridge the main field of research under the direction of Professor M. Ryle has been the study of the radio "stars". Accurate positional measurements in 1950 led to the discovery that the intense source in Cygnus was an extra-galactic nebula at the very great distance of 500 million light-years; its radio emission must be some million times more intense than that from our own galaxy and similar sources should be detectable at distances beyond the reach of the largest optical telescopes. It therefore appeared possible that radio observations might yield evidence favouring some cosmological theories rather than others, and so help solve problems that have so far remained unsolved by optical astronomy.

Before any such investigation could be made it was, however, necessary to establish what fraction of the observed radio sources might be similar to that in Cygnus, for other sources had been identified with supernova remnants in our own galaxy and with nearby galaxies; if such sources predominated there would be little likelihood of detecting any cosmological effects. The first stage in this programme was initiated in 1953 with the construction of a large interferometric radio telescope, the first in the world to have a collecting area of one acre. Observations with this instrument over the period 1953–57 provided much new information on the radio sources and suggested that a large number of the sources were indeed powerful extra-glactic sources like that in Cygnus. The observations also supported cosmological models of the universe which associate the recession of the galaxies with a progressive decrease with distance in the average density of matter in the universe.

These observations could not, however, be regarded as conclusive and a new and much more powerful instrument was designed during 1955 and built during

1956–57 at the new observatory established with support from D.S.I.R. and Mullard Limited. This new instrument (see Plate 4) operates on an entirely new principle known as aperture synthesis in which observations that would have been obtained from a very large telescope are "synthesized" by combining those made with two smaller instruments, one of which is movable. In resolving power the instrument is equivalent to two aerials, each of eight acres in area, arranged as an interferometer.

The telescope has allowed the observation of sources very much weaker than those observed in any of the earlier surveys and has enabled many detailed studies of sources to be made, as well as a much more critical examination of the cosmological problem. It has been possible to show conclusively that most of the radio stars are in fact extra-galactic nebulæ of very great power, and the observed distribution of the sources with intensity indicate that it is now difficult to accept the original version of the steady-state model of the universe.

In addition to this radio-star observation galactic emission at long wavelengths is being studied with a new large instrument, also employing the principle of aperture synthesis. Observations have also been made to determine the radio spectrum of the galactic background radiation and also of radio stars. By observing the scattering of the radiation from a radio star through the solar corona it has proved possible to explore the extension of the sun's atmosphere into the interplanetary gas as far out as the orbit of Mercury.

Radio Astronomy at Manchester University

During the four years under review D.S.I.R. has been one of the major sources of funds for radio-astronomy research at the Nuffield Radio Astronomy Laboratory at Jodrell Bank under the direction of Professor Sir Bernard Lovell. The work has covered a wide range of subjects including studies of the extra-terrestrial radio sources, hydrogen-line surveys of the galaxy and external galaxies, radar studies of the moon and Venus, radar studies of meteors and the aurora, combined radar and photographic studies of bright meteors, the observation of the temperature and pressure and winds at high altitude by the radar observations of meteors, and the study of the ionosphere by radar using the moon as a reflector and also by observing the scintillation of radio stars.

Work on extra-terrestrial radio sources includes a study of the radio emission from normal galaxies. From detailed surveys of twenty spiral galaxies the ratio of the radio to the light flux has been established for two different types of spiral, and it has been shown that these galaxies have extended coronæ. Detailed measurements of the distribution of intensity across the two intense radio sources in the nebulæ Cygnus and Cassiopeia have been made at wavelengths between 3 m and 10 cm. In addition the apparent angular diameter of more than 300 sources has been measured with an interferometer of extremely high resolving power. At its maximum resolving power this instrument has shown a significant number of sources to have diameters less than 2 seconds of arc. This work drew attention to a source (3C295) which was subsequently identified optically by Minkowski and was shown to be associated with a galaxy that appears to be moving from the Earth at almost half the speed of light.

A detailed study of the absorption spectrum of the Cygnus source has shown that the red-shifted absorption line of neutral hydrogen cannot be observed. This result shows conclusively that previous reports that this line could be observed are incorrect.

It has been shown by a search for the Zeeman effect in the 21 cm radiation from interstellar neutral hydrogen that the interstellar magnetic field in certain regions of the galaxy is less than 10^{-5} gauss.

Work on the solar system and the aurora includes radar studies of the moon and these have shown how the reflected energy of radar impulses is distributed across the moon; they have also made possible measurements of the total electron content of the ionosphere by observation of rotation of the plane of polarization of the signals.

Radar echoes have been obtained from Venus and an improved measurement has been obtained for the distance of the sun from the earth. An extensive radar study of the aurora borealis has been carried out at Jodrell Bank and also in Antarctica. A correlation between auroral activity in the two hemispheres has been established.

The radio echo studies of meteors have been continued with equipment which is capable of delineating the orbits of individual meteors. With this apparatus the orbits of many thousands of sporadic meteors have been established, and the results show that an unusual class of short-period, solar-system orbits are present amongst the fainter magnitudes. Combined radio-echo and photographic studies of meteors have been made using a Schmidt camera at a remote site. This work has been designed to investigate the relation between the ionizing and luminous efficiencies. Investigations of the characteristics of the radio echoes have been used to make a systematic study of the wind distribution in the 100 km region of the ionosphere for several years. This work has also included the measurement of the variations of other ionospheric parameters such as diffusion, temperature and density using this meteor technique.

The radio telescope (Plate 5) has also been used in radio and radar studies of Russian and American earth satellites and space probes. Among the more interesting results have been the measurement of the velocity of impact of the Russian Lunik II with the moon and the tracking of the American space probe Pioneer V to a distance of 23 million miles from earth. About 10 per cent of the operational time of the telescope has been allocated to work on satellites and probes.

BIOLOGY

Number and Value of Grants Awarded

1956/57 (Oct–Sept)		1957/58 (Oct–Sept)		1958/59 (Oct–Sept)		1959/60 (Oct–Sept)	
No.	Value	No.	Value	No.	Value	No.	Value
14	£37 133	12	£36 119	51	£105 240	45	£221 047

The major part of D.S.I.R. support in biology has been used for two main purposes—to engage research assistants and to purchase apparatus of a size and type which has not been obtainable from normal university sources. The need for research assistants arises from the demand made in this field for continuity of attention, for instance in the maintenance of cultures, which often cannot be given by university staff having teaching and administrative duties. Requests for grants for apparatus reflect a trend towards the greater use of modern techniques. The awards made have therefore helped the inception of types of research which otherwise could not easily have been undertaken by the teaching staff in universities.

Electron microscopes have been in great demand, especially for the study of the fine structure of plant and animal cells in relation to function, and funds have also been required in some cases for electron microscopists, particularly where the apparatus is shared by workers in several departments. Already electron microscopy has revealed an extraordinary amount of organized structural detail in cells, especially in the cytoplasm, and it is encouraging that biologists, some of whom must rely on morphological studies as a background to other work, are ready to exploit this relatively new tool. However, it is necessary to ensure that the research effort and resources expended on costly instruments is not at the expense of other promising research. D.S.I.R. grants for other sorts of special but less costly microscopes such as interference and phase contrast types are in less demand because these can usually be bought from university funds.

The use of high-speed centrifuges for the preparation and purification of enzymes and for the sedimentation analysis of macromolecules is increasing. An important objective of these researches is a detailed understanding of the mechanism of enzyme action and of the breakdown and synthesis of materials within living cells. Other promising types of research, especially in biochemistry and physiology, have required the provision of newer and more expensive types of physical apparatus, such as the mass spectrometer, X-ray diffraction apparatus, ultra-violet and infra-red spectrophotometers, electrophoretic apparatus and oscilloscopes. A grant of £60 000 was made to the Physics Department, St. Bartholomew's Hospital, for an electron linear accelerator, to study the effects of very high energy radiations on living cells and organisms.

Most grants for research in biology are fairly small, more than two-thirds being under £3000, and this reflects the individual rather than team approach to research which is still widespread in the subject. The marked increase in applications and awards in the four years under review indicates that the potential in universities and colleges for biological research has been neither fully used nor fully satisfied. Some of the factors contributing to this situation, such as lack of equipment and assistance, are being tackled by means of special research grants, while others, such as shortage of space, are being met by funds made available to universities and colleges through the U.G.C.

An indication of the wide variety of work supported by D.S.I.R. is given in the following examples of current work.

Cell Mitosis

One of the electron microscopes provided by a D.S.I.R. grant has been used for cytological research by Professor C. D. Darlington of Oxford University. For just over a year it has been employed mainly to follow changes in the structure of cells during their division (mitosis).

The breakdown of the nuclear membrane in the early stages of division and its reconstitution later has been studied. Two electron photomicrographs illustrating this are shown in Plates 10 and 11. The first photograph (at 1850 magnifications) shows cells from a barley root either with "resting" nuclei (nuclear membranes intact) or with the nuclear membranes just beginning to break down during the earliest phase of mitosis. The thin, almost circular nuclear membranes and the straight, relatively thick cell walls are clearly visible. A much later stage in mitosis is shown in the second photograph which was taken when division had been almost completed. Two daughter nuclei which have resulted from the division of the mother nucleus are shown, and it can be seen that the two nuclear membranes do not yet completely enclose the paler masses of the two groups of daughter chromosomes. A new cell wall is forming between the daughter cells, the first indication of its position is given by a series of vacuoles or bubbles. Evidence collected in this investigation links the formation of these bubbles with the Golgi bodies, so much discussed by animal cytologists and which at other stages can be seen scattered among other, larger, egg-shaped cell inclusions (mitochondria). Other, unconnected researches have indicated that the mitochondrion is what might be termed the power-house of the cell; it produces energy which can then be used in all the various and complicated procedures on which life depends.

The Development of Song in Birds

A problem of great biological interest is the relationship between the inborn and acquired behaviour of animals, or how the unlearnt behavioural capabilities and tendencies of an animal are affected by what it learns during its life. The experimental study of the development of song in passerines (sparrow-like birds) has been shown by Dr. W. H. Thorpe (Cambridge University) to shed interesting light on this problem.

In terms of neuromuscular organization and control, the song of birds is an extremely complex phenomenon. Experiment has shown that in the chaffinch, as in many other birds, there is a basic song pattern, which is innate in the sense of being coded genetically and present in the central nervous system, and that this innate song can be produced even though the bird is reared in complete acoustic isolation. This song is, however, very much simpler than the song of the species as normally heard in the wild, although it is almost identical with the normal song of another species, the blue chaffinch (*Fringilla teydea*) of Tenerife. All the fine detail of the normal chaffinch song, including the details which are characteristic of individual birds, are learnt as a result of singing in competition with other members of the species during the first breeding season, when the birds first compete for territories, which they do largely by song contests. It has been shown that the birds restrict their imitation to the songs of members of the same species with whom they are in contact; new songs and song patterns can be learnt only during the first 13 months of life and in that time there is a peak period of learning activity during which the bird may acquire a repertoire of up to six different songs; and that this period of high learning ability is brought to an abrupt close by internal factors (certainly controlled partly by hormones) which are now being investigated. The subject is of particular theoretical interest in that the results show very clearly how an inborn behaviour pattern may be elaborated and "completed" by learning processes, and also that this learning is of the "unrewarded" type since nothing in the way of conventional reinforcement or reward is present. Finally, the restriction of learning ability to a brief and sharply defined period in early life recalls the type of learning known as imprinting, and helps to throw light on the general problem of sensitive periods in the process of learning, which is of general interest as well as of particular concern to psychologists and others.

Bird Migration

The migration of birds and other animals is a topic which has puzzled man for a long time and is now being studied by means of radar. By means of a grant, D.S.I.R. has helped Dr. D. L. Lack (Oxford University) and his co-workers to make use of costly radar equipment, with full co-operation from R.A.F. Fighter Command.

Observers have at different times scanned the Channel, the southern North Sea, the sea off north-east Scotland, and Shetland by means of radar. The previous picture of migration into and out of Britain, which was based on visual evidence, was found to need important corrections, and some large, regular, but previously unknown movements were demonstrated. Repeated observations in the southern North Sea have allowed analysis of the weather factors influencing migration. The previous visual evidence has been proved to be misleading for this purpose. New light has also been thrown on the navigation of small land-birds over the sea, out of sight of land. In the southern North Sea, migrant birds normally travel on a constant heading with no allowance for lateral displacement by cross-winds, while only rarely are they disoriented even in fully overcast conditions. Off north-eastern Scotland birds disoriented in fog at night have been watched reorienting by day. Off Shetland, where land-birds from Norway over 200 miles away have sometimes been located far west of the islands by daybreak, migrants proceeding west at night rise high and change their direction at dawn. Between northern France and Kent some daytime migrants fly on a changing course from WSW to WNW. The height of migration is now known to be usually below 5000 feet and rarely up to 21 000 feet. Radar has also thrown important new light on the nocturnal ascents of swifts in summer, many of which spend every night on the wing, often over the sea.

Fouling by Marine Organisms

Surface fouling by the settlement of marine organisms such as barnacles is an important economic problem. Dr. D. J. Crisp (University College of North Wales, Bangor) is studying, with the aid of a research grant, the seasonal succession of fouling organisms at representative localities around the British coast, including some of the major ports. This work will link up with similar investigations being carried out by other workers along the coastline of western Europe. The results should be of value to port and shipping authorities as well as to biologists.

Around Britain, although each locality has its distinctive character, fouling is generally more intense in southern England, more especially so in artificially warmed areas where immigrant forms frequently appear. A number of studies have been made of the behaviour of the larvæ of these organisms during settlement to ascertain how the physical and chemical properties of a surface influence settlement. Contrary to expectation the larvæ of a number of fouling organisms show a clear preference for smooth rather than rough surfaces. Some organisms settle readily only on surfaces which have acquired a natural film of slime, others avoid such films or are indifferent to them. An interesting observation concerns the response of certain species normally found on seaweed to an extract of the weed. Such extracts contain substances which in very small amounts will accelerate settlement, and which can be transferred to otherwise unattractive surfaces (Plate 8).

There is much diversity in the behaviour of fouling organisms. Copper, which is commonly used to prevent fouling, does not repel the larvæ of barnacles, but eventually poisons them if its concentration is high enough. The sensitivity that these larvæ show to small differences in surface properties suggests that substances may be found with specifically repellant action at much lower concentrations than those which are toxic.

Fine Structure in Plants

A D.S.I.R. grant for research into the relationships between fine structure and growth in plants and to further our knowledge of the mechanical properties of cell walls, formed the basis of the Sub-Department of Plant Bio-physics which has grown up under Professor R. D. Preston in the Botany Department of Leeds University. The equipment provided included an electron microscope, X-ray generators, X-ray microdensitometer and a micro-extensometer. The Sub-Department has been able to contribute substantially to knowledge of the fine structure of cellulose and of changes in its organization during growth in a very wide range of plants, to extend its work into studies of the mechanical properties through which fine structure is involved in growth processes, and to make fundamental contributions to our knowledge of water movement in plants and of solute transport in the phloem.

Interest has centred largely on seaweeds and the fine structure and chemical composition of the walls of many species have been elucidated. The most recent achievement is the elucidation of the structural changes involved in growth of the very firm walls of the Cladophorales (green, marine algæ) and the demonstration that spiral growth occurs in these plants. It is now quite clear that this spiral growth (and possibly all spiral growth in plants) results from an interplay between osmotically induced pressures and the mechanical properties of cell walls, as dictated by their fine structure.

Flora of Europe

A fundamental need in biological and other research is the identification of species. It is surprising to learn, therefore, that there has been no general account of the flora of Europe in over 180 years, since the time of Linnaeus. A noteworthy project supported by a grant from D.S.I.R. involves support for a group of British botanists, led by Professor T. G. Tutin of Leicester University and Dr. V. H. Heywood of Liverpool University, whose object is to prepare a concise and systematic account of the vascular plants of Europe.

Published literature on the systematics, distribution and variation of European plants is extensive and diverse, but no serious attempt has ever been made to extract the essentials, placc them in order, and publish the results in a modern and rational way. Basic information, it has been found, is often lacking and can only be obtained by extensive research. Several problems fundamental to the whole of botanical taxonomy have been brought to the fore during this work and these have induced a number of botanists to make co-operative attempts to reach practical solutions. Taxonomists, including both established workers and research students, have been stimulated to undertake special research which will benefit European taxonomy as a whole, and also in the long term such subjects as evolution, genetics, forestry and agronomy.

The "Flora Europaea" is expected to consist of 4 volumes of some 1200 pages each, in which perhaps 17 000 plants will be described and indexed in a way that enables them to be readily identified. Other information to be given includes notes on the range of variation, summaries of geographical distribution and detailed country-by-country occurrence, chromosome numbers and references to important monographs and revisions.

The project is sponsored by the Linnean Society of London, and an organizing and editorial committee has decided on the principles to be followed in writing and editing the "Flora Europaea". The committee has several advisory editors, who are all eminent European botanists, and one or two regional advisers in each country in Europe. By pooling the knowledge of this experienced group of botanists it is hoped to produce a work that will make a substantial contribution to the subject.

CHEMISTRY

Numbers and Values of Grants Awarded

1956/57 (Oct–Sept)		1957/58 (Oct–Sept)		1958/59 (Oct–Sept)		1959/60 (Oct–Sept)	
No.	Value	No.	Value	No.	Value	No.	Value
24	£79 409	40	£146 051	59	£270 800	73	£254 560

The major development in chemistry since World War II and particularly in the last few years has been the application of an increasing range of physical methods to the solution of more difficult problems of molecular structure and of analysis. The regulations permitting D.S.I.R. grants to enable investigators to "take advantage of developments in apparatus offering improved techniques in promising lines of research already established under the investigators" have met the needs of the modern research chemist who requires such equipment as nuclear magnetic resonance and mass spectrometers, ultra-violet and infra-red spectrophotometers, electron microscopes and X-ray diffraction equipment if he is to make adequate progress in his researches. An example of this type of grant was made in 1957 to Imperial College, London, for the purchase of a high resolution nuclear magnetic resonance spectrometer which Professor G. Wilkinson has applied to several problems in connection with transition metal compounds and complex ions.

D.S.I.R. also provides support for the development of novel or modified equipment and two such examples concerned with techniques used by chemists are shown below in the cases of Dr. R. E. Richards and Professor M. C. R. Symons.

The last example relates to an inter-disciplinary subject—high-pressure chemistry and geochemistry—an aspect of university research which D.S.I.R. wishes especially to encourage.

Nuclear Magnetic Resonance applied to Transition Metal Chemistry

One of the most important uses of the nuclear magnetic resonance spectrometer at Imperial College, London, has been for the characterization of chemical species in which a hydrogen atom is bound to a transition metal atom. It was discovered some years ago that the nuclear magnetic resonance spectra of such hydrogen atoms have a unique very large shift towards high magnetic fields and further work has substantiated the characteristic nature of this shift. By this means very unstable, air-sensitive and even unisolable species in quite low concentrations in aqueous or other media have been shown to be hydride complexes. Several species previously considered to contain metals in lower oxidation states have readily been shown to be hydrides.

The spectrometer has been particularly useful for structural studies on organometallic compounds of transition metals, especially those of olefins and other unsaturated radicals such as cyclopentenyl and cyclohexadienyl. The nuclear magnetic resonance spectra have allowed rapid and unequivocal assignment of configurations in a number of cases where other methods would have failed. Considerable progress has been made towards complete assignments of the spectra in several very complicated systems such as those of the azulene metal carbonyls. As well as hydrocarbon complexes, fluorinated olefin complexes have been studied through the F^{19} resonance.

A useful procedure has been developed for the determination of magnetic susceptibilities using very small amounts of material, and among other things this method has been applied to demonstrate the susceptibilities of reduced vitamin B_{12} species.

A further application has been in the study of chemical shifts in ligand protons in paramagnetic transition metal complex ions. Here very large chemical shifts are observed owing to the effects of the unpaired electron spin, and it has proved possible to estimate the charge density at particular carbon atoms in the ligand in complexes such as those of ferric iron with substituted *o*-phenanthrolines.

Recently work has been initiated on protonation reactions of transition metal complexes in very strong acids such as concentrated sulphuric acid, tri-fluoro-acetic acid or boron trifluoride hydride. From the high-field shift of the proton resonance it has been shown that many species with non-bonding electrons can be protonated; thus $Fe(CO)_5$ gives the ion $HFe(CO)_5^+$. Protonated species of this type are probably involved in many acid-catalysed reactions. It has also been shown that the borohydride ion can act as a source of hydride H^- ion in aqueous solutions, and nucleophilic displacement reactions in complex ions can be studied.

Development of Nuclear Magnetic Resonance Techniques

Nuclear magnetic resonance methods have been developed during several years by Dr. R. E. Richards in the Physical Chemistry Laboratory, Oxford. In 1954 it was clear to Dr. Richards that the study of chemical shifts would become of great importance and that accurate measurements of these shifts could not be made with the simple equipment then available. It was calculated that a permanent magnet could be built to provide magnetic fields sufficiently stable and homogeneous for this purpose, and such a magnet was designed in collaboration with Mr. A. J. Tyrell and Mr. B. A. Evans of Mullard Limited. Mullard Limited undertook to manufacture the magnet, the cost being met by grants from Shell Petroleum Limited, the Royal Society and D.S.I.R.

This magnet has been the essential part of a new type of high-resolution nuclear magnetic resonance spectrometer which has been developed in the Oxford Physical Chemistry Laboratory and which has great stability of magnetic field and resolving power combined with a routine resolving power of 1 in 10^8. The instrument has proved to be extremely reliable and has been in continuous use in the Laboratory since 1957, and in the period 1957–60 some twenty papers have been published concerned with various applications of high-resolution nuclear magnetic resonance to chemical problems. Development of the spectrometer has continued and its convenience and performance has been steadily improved.

During this period exploratory work was carried out on chemical shifts of nuclei other than hydrogen and fluorine. For this purpose simple laboratory-built apparatus was used, but it became clear that if greater sensitivity could be achieved there might be a great range of chemical problems which could be studied in this way. Further grants from D.S.I.R. have enabled an electro-magnet to be purchased to give the high field required (14 000 gauss), and a wide-line spectrometer was built which has greater reliability than previous equipment. Measurements on cobalt and thallium chemical shifts have provided information about the structure of cobalt complexes and about ion-pair formation in strong solutions of thallous salts. Further applications of this new and sensitive equipment are being found.

Development of Electron Spin Resonance Techniques

A new and increasingly important field is electron spin resonance, and of particular interest is a grant made in 1959 to Dr. (now Professor) M. C. R. Symons. Early work by Professor Symons in this field was carried out using the instruments in the Department of Electronics, University of Southampton, which were constructed by Dr. (now Professor) D. J. E. Ingram. (This work has been supported by D.S.I.R.) When Dr. Ingram was appointed to a chair at the University College of North Staffordshire, Professor Symons' work in this field was continued with financial assistance from Imperial Chemical Industries Limited and D.S.I.R.

An 8-inch electromagnet of British manufacture has been purchased and a 3-cm spectrometer using 100 kcs modulation has been constructed. This is now working satisfactorily at Leicester University.

High-pressure Chemistry and Geochemistry

In recent years attention has been drawn to the needs for more inter-disciplinary scientific research. Discussions at Leeds University in 1958 between Professor W. Q. Kennedy, Dr. E. G. Cox (then Professor Cox but now Secretary of the Agricultural Research Council) and Dr. R. S. Bradley led to work on high-pressure chemistry and geochemistry being started in the Department of Chemistry. With the aid of grants from the U.G.C. and D.S.I.R. rooms in the new wing of the chemistry building have been equipped for such work and apparatus has been installed. This equipment includes an X-ray diffractometer and fluorescent spectrometer, twelve stellite hydrothermal bombs capable of withstanding pressures of 1000 atmospheres at 950°C and 5000 atmospheres at 750°C with ancillary pumping, pressure measuring and temperature recording and control equipment, two 50-ton presses for compressing small samples at pressures up to 100 000 atmospheres, a micro-press for direct X-ray work under pressure, an induction vacuum furnace and a platinum furnace.

The work under development includes the study of the semi-conductivity of compressed solids under pressures up to 50 000 atmospheres; electronic, protonic and ionic conductivity are beiug especially studied. At present one set of observations has been nearly completed on co-ordination complexes with π bonding, and it is believed that the use of high pressure, which has a very marked effect on the electronic conductivity, will help to elucidate the mechanism of electron transfer. A study on fayalite and on fayalite-forsterite solid solution has been started, the results of which should be of considerable interest in connection with the structure and properties of the Earth's mantle. The 50-ton press for external heating has been designed for the study of high-pressure polymorphic forms, for example those of the nitrides and of compounds of low co-ordination number. The micro-press for direct X-ray work will be used for the study of polymorphic change in molecular solids, including hydrogen-bonded compounds, and in co-ordination compounds.

In geochemistry the present studies at Leeds with this apparatus are on phase equilibrium relationships in systems containing CaO–CO_2–H_2O and other components. This work follows on from the recognition of low temperature melts (650°C) through a wide range of pressures in the system $CaO–CO_2–H_2O$. CO_2 and H_2O are the most abundant "volatiles" in the earth's crust; more experimental data in systems containing two volatile components are required before geologists will be able to apply experimentally determined pressures and temperatures to natural processes. The study of systems involving $CaO–CO_2–H_2O$ and additional components P_2O_5, MgO, SiO_2 and aegirine ($NaFeSi_2O_6$) is yielding information about the physical and chemical nature of carbonatite magmas, the petrogenetic links between carbonatite and silicate magmas, the effect of volatiles on dehydration and decarbonation reactions of importance in metamorphism, and minerals of the apatite family.

GEOLOGY AND GEOPHYSICS

Number and Value of Grants Awarded

1956/57 (Oct–Sept)		1957/58 (Oct–Sept)		1958/59 (Oct–Sept)		1959/60 (Oct–Sept)	
No.	Value	No.	Value	No.	Value	No.	Value
6	£10 971	8	£53 450	24	£108 512	25	£153 334

During 1956–1960 grants for geological work have been awarded for a wide variety of research projects. Among the more important of these has been support for the development of techniques in the discovery and study of economically useful earth-materials, particularly the metallic and non-metallic mineral deposits. In pure geological research, grants have been awarded for studies dealing with the age, relationship and distribution of rocks in the U.K. and in critical areas overseas and with the bearing of their fossil content on biological theory and on past climates and geographies. Geophysical investigations into the constitution of the earth and of the sub-oceanic rocks have included support for gravimetric, magnetic, seismic and palæomagnetic studies. All these investigations have been helped along by a considerable increase in the number and size of D.S.I.R. grants for special apparatus, equipment, staff and travel.

A special attempt has been made to support university research in fields where the effort has been considered insufficient. Geochemistry and high-pressure-temperature work on rocks and minerals, as well as submarine geology, have received special attention. Although it is too early to record the results of much of the work which has been supported since 1956 there are several significant researches, some of which began before this time, and which have advanced sufficiently to be briefly described. These are geochemistry in mineral exploration, age determination of rocks and palæomagnetism, and a short-term project—the development of a differential proton magnetometer.

Geochemistry in Mineral Exploration

The application of the principles of geochemistry in the search for mineral deposits is as old as man's first use of metals, but it was not until the recent evolution of fundamental geochemistry as an organized branch of earth science that these principles were first exploited scientifically to assist in locating the new mineral resources essential to continued industrial development.

Geochemical exploration entails the search for anomalies in the natural dispersion pattern of metals, using rapid methods of sample collection and analysis. Since the metal concentrations involved are often very minute the provision of suitable analytical techniques is a basic problem. This has been answered for many metals by specially adapting classical methods of colorimetry, chromatography, spectrography and other instrumental techniques. In fact it was not until the analytical achievements of some 15 years ago that geochemical methods began to develop as a really effective tool in mineral exploration.

Since 1954, grants have been awarded by the Colonial Office and D.S.I.R. to Professor D. Williams and Dr. (now Professor) J. S. Webb of the Geochemical Prospecting Research Centre, Imperial College, to assist in a continuous programme of research in applied geochemistry. During the course of this work field studies have been undertaken in many parts of Africa and the Far East, covering a wide range of conditions and a variety of metals including lead, zinc, copper, cobalt, nickel, tin, tungsten, molybdenum, niobium, beryllium and chromium, in addition to arsenical and antimonial gold ores.

A major obstacle to mineral exploration in tropical terrain is the frequent characteristic combination of deep weathering and persistent soil cover. As a result, visible surface indications of mineral deposits may be lacking and adequate geological mapping quite impossible. Considerable attention has been given, therefore, to geochemical dispersions in soil, and it has been possible to establish satisfactory prospecting techniques and criteria for interpreting soil survey data in terms of mineral deposits in the underlying bedrock. Results obtained in the Rhodesian Copperbelt have been particularly encouraging and geochemical soil surveys for copper ores are now employed there by industry as a standard practice involving the collection of about 1 100 000 samples a year.

During the course of erosion the products of weathering are funnelled into the drainage system and water and sediments in the streams down-drainage from mineralized bedrock will tend to have higher metal contents than streams draining from unmineralized catchment areas.

The first demonstrations of the geochemical application of these principles to mineral reconnaissance in Africa and the Far East were made by the Imperial College Centre in the copper-cobalt districts of Rhodesia, Uganda and Borneo, and in the search for nickel in Tanganyika and for niobium and beryllium in Central and East Africa. By virtue of the extensive anomalous drainage trains, commonly from about half a mile up to five miles or more it is possible to use a very low density of sampling, resulting in extremely rapid and low cost reconnaissance coverage of large areas. Geochemical drainage surveys based on the results of this work have subsequently been carried out by several mining companies.

Geological Age Determinations in Oxford

Methods for determining the absolute age of rocks and minerals give a new line of approach to the problems of the origin, history and structure of the continents and of the processes which have shaped the surface of the earth. They will be particularly valuable if they make possible a world-wide correlation of Pre-Cambrian rocks in which fossils are absent. Little work on determination of age has been done in Britain so far, but a start has been made in particular aspects of it at the Atomic Energy Research Establishment, Harwell, by the Atomic Energy Division of the Geological Survey, and in Oxford and Cambridge Universities.

The largest effort of this kind is being made in Oxford University under Professor L. R. Wager; there the potassium-argon and rubidium-strontium methods have been introduced in the Department of Geology and Mineralogy, partly with the help of D.S.I.R. grants. Commonly occurring minerals which can be dated by these methods include the mica groups and the potassium feldspars, both of which are widely distributed in igneous and metamorphic rocks.

Both methods have been used to determine the age of certain British granites. Of particular interest are the ages of the Dartmoor granite, 280 million years old, and the Shap granite (Westmorland), 390 million years old; these provide valuable fixed points on the geological time scale on account of their close stratigraphic assignment. The ages obtained represent the time of crystallization of the granites from a molten condition and the results from the two independent methods agree well.

The existence of very ancient rocks, at least 2500 million years old, has been established in the Lewisian basement complex of North-west Scotland. Further important mountain-building periods occurred in Scotland about 1600, 470 and 420 million years ago respectively. For these measurements minerals from the metamorphic schists and gneisses were used. The potassium-argon method gives the date of the latest major metamorphism, that is the latest chemical and physical reconstitution of the rocks under conditions of high pressure and temperature, but without melting, while the rubidium-strontium method, which may give a discordant age-pattern if the whole rock and different minerals from it are separately investigated, often provides information on the succession of metamorphic events in the area. Methods for interpreting rubidium-strontium age-patterns are still in an early stage of development, but there is no doubt that this is one of the most significant recent advances in geological-age work, and several laboratories are participating in it.

A further Oxford investigation is based on the isotopic analysis of lead from commonly occurring non-radioactive sulphide minerals such as galena (lead sulphide). A large number of measurements from the British Isles indicate six distinct periods of mineralization within the last 500 million years. Studies of this kind are yielding fundamental information on the ultimate origin of a common type of mineral deposit.

Palaeomagnetism

For the last hundred years it has been known that certain rocks possess a remanent magnetization, but only in the last ten years has research expanded to the point where important geophysical discoveries have been made. Helped by D.S.I.R. grants, groups of British workers at Imperial College, London, King's College, Newcastle, and Cambridge University have played the key rôle in this achievement. They have systematically studied the natural directions of magnetization of lavas and red sandstones of many geological ages and in many continents.

Unmetamorphosed igneous rocks such as lavas acquire their magnetization by cooling from temperatures above the Curie point of the iron oxide minerals; this "thermo-remanent magnetization" process can be demonstrated and studied in the laboratory. Red sandstones acquire their magnetization either by the orientation of the tiny magnetized grains during deposition or as a result of the chemical changes which produce the weakly magnetized grains of hæmatite from the non-magnetic hydroxides of iron between the quartz grains. In both kinds of rocks the natural magnetization can often be shown to be very stable either by studies of the present magnetization of folds and conglomerates or by laboratory tests.

Studies of the Tertiary lavas of Iceland and the late Tertiary basalts in other parts of the world showed, as was suggested by the theory of the geomagnetic field, that for times short on the geological scale, perhaps some thousands of years, the average field of the earth is that of a dipole parallel to the geographical axis. However, as work on the Tertiary dykes of Northumberland had also shown, the lavas appear in groups magnetized parallel and antiparallel to the present earth's field. The discovery of many other reversals of polarity of magnetization in igneous and sedimentary rocks of most geological ages is most plausibly explained by reversals of the polarity of the earth's magnetic field at irregular intervals of the order of millions of years. However the alternative possibility of this reversed magnetization of rocks being due entirely to complicated processes in the iron oxide minerals cannot yet be finally excluded.

Tertiary time is only the most recent one tenth of the comparatively short part of the earth's history which is adequately recorded in rocks. Mesozoic, Palaeozoic and late Pre-Cambrian rocks are found to be magnetized in directions which get progressively farther away from the present field as one goes backwards in time. This important observation was first made on the geological column in Great Britain and was soon established by British workers also in North America, India and Australia. The simplest hypothesis to explain these results, i.e. that the geographical axis had moved gradually with respect to the earth's crust, was not entirely adequate to explain the results, especially from the southern hemisphere, and another old geological hypothesis, Wegener's continental drift, had to be invoked. More complete palaeomagnetic surveys are needed, especially from South America, Africa and Asia, before continental drift is fully established, but it now appears plausible.

There are many problems in the study of palaeomagnetism requiring further work. For example, considerable steps are being taken in developing laboratory methods for "the magnetic cleaning" of rocks, that is removing unwanted secondary magnetizations acquired recently. Further study is also required to find why the intensities of magnetization in one rock series vary by factors of 100 often in quite small thicknesses of rock. In addition the physics of the magnetization processes in red sandstones and lavas, although considerably advanced by Neel's theories, is still not well understood and hinders the full explanation of how the magnetization of rocks was induced initially.

Palaeomagnetic studies have put new life into studies of palaeoclimatology, especially those aspects which give information about the former latitudes of the continents, such as the distribution of evaporites, corals and palaeowind directions. The subject has stimulated a new search for other evidence of continental drift and polar wandering and the International Union of Geodesy and Geophysics project for international co-operation in studies of the upper mantle may well help to explain the physical causes.

Development of a Differential Proton Magnetometer

Since the observation in 1954 by Packard and Varian of free-precession in the earth's magnetic field of protons in a water sample, proton magnetometers have been used to an increasing extent in geophysics and in mineral prospecting. Aided by a D.S.I.R. Research Grant, the Archaeological Research Laboratory of Oxford University under Dr. E. T. Hall and Dr. M. J. Aitken has applied the phenomenon of proton free-precesssion to the measurement of magnetic gradients and to the direct measurement of the difference between the magnetic field strengths at two points. In geophysics these types of measurement have particular application in earthquake research where it is required to separate the localized magnetic effects of an incipient volcanic eruption from the widespread diurnal changes produced by currents in the upper atmosphere.

In the course of this research a remarkably simple form of differential proton magnetometer (Plate 15) has been developed. It consists of two bottle-detectors carried at either end of a five-foot "Dural" rod, a transistorized high-gain selective amplifier, and an earphone. The two detectors are connected in series to the amplifier and, when both detectors are in the same magnetic field strength, a steady note of several seconds duration is heard in the earphone. If the field strengths differ slightly the signals from the two detectors, now being of slightly different frequencies, slowly get out of step, and the note ceases prematurely. "Beats" are heard if the field strengths differ by 10^{-4} oersted or more. Although this very simple instrument is not accurately quantitative, it is adequate for the location of appreciably magnetic archaeological features such as pottery kilns.

LOW-TEMPERATURE AND SOLID-STATE PHYSICS

Number and Value of Grants Awarded

1956/57 (Oct–Sept)		1957/58 (Oct–Sept)		1958/59 (Oct–Sept)		1959/60 (Oct–Sept)	
No.	Value	No.	Value	No.	Value	No.	Value
19	£115 444	10	£24 517	26	£312 047	51	£188 611

In recent years the study of solids has become one of the largest and most active fields of research in physical science. The areas it covers are broadly classed either as solid-state physics or as physical metallurgy, but there has been a considerable unification of these two subjects as knowledge has deepened about the atomic structure of matter and about the ways in which crystalline defects of an atomic scale of magnitude determine most of the bulk properties, including those of technical importance, in solids. Much of what has traditionally been regarded as low-temperature physics is also closely related, since at sufficiently low temperatures all matter exists in the solid state or, as in the case of helium, as a liquid with properties analogous to certain quantum effects in solids.

The study of the physical properties of solids is a field of research well suited to academic institutions. The problems are fundamental and demand a full understanding of modern physical science. The apparatus required (apart from nuclear reactors and low-energy accelerators for radiation damage studies) has not yet grown beyond the conventional laboratory scale, and is usually of the type that investigators can assemble themselves and put into use within a few months; and there is a technological stimulus to such studies because of the need for new electronic and magnetic materials, creep-resistant alloys, and radiation-resistant materials. Therefore it is not surprising that requests for funds for research in low-temperature and solid-state physics has risen over the four years under review.

Particularly strong support has been given to electron microscopy and grants have been awarded during the period 1956–60 for nine electron microscopes at academic institutions in various parts of the United Kingdom, particularly university departments of metallurgy. The recent striking improvements in electron microscopic technique have opened a new world of exploration of the fine structure of solids, particularly metals, alloys, and polymers, which is of great scientific interest as well as of technological value. This stimulation of academic research in this field has now been followed by a large increase in the use of electron microscopy in industrial research laboratories.

Extensive support has also been given to studies of the fundamental electronic structure and thermal behaviour of crystalline solids. Cyclotron resonance of electrons precession and nuclear alignment, all in strong magnetic fields, have proved particularly valuable for studying the distribution of electronic states of motion in metals (with some surprising results), the magnetic structure of solids and radiation damage. On the other hand fewer applications than might have been expected have been received for researches on semiconductors; it may be that there is some feeling, rightly or wrongly, that basic and applied research in this field, now pursued on such a vast scale in individual laboratories, has passed beyond the scope of small academic laboratories.

The progress of some of the researches in the field of low temperature and solid state physics supported wholly or partly by D.S.I.R. grants is described in the following paragraphs.

Electron Microscopy of Metals and Other Materials

Since the war high-resolution electron microscopes have been developed and applied to an increasing extent to the study of microstructure of materials. In most of the early researches replicas taken from the specimen were examined, giving detailed information about the surface topography. This method was used successfully in studies of slip line distribution, for example. The development of extraction replicas enabled great advances to be made in the study of precipitation processes, particularly in steels, but the early stages of the reactions could not be investigated with these techniques.

Around 1955 the first attempts were made to observe defects and precipitates directly in thin metal foils, by transmission in the electron microscope. Using this technique in 1956, dislocations were observed for the first time directly in thin foils of aluminium and of stainless steel. These and subsequent experiments at once showed the transmission electron microscope technique to be a very powerful tool for the study of defects in crystals.

Since that time the technique has developed very rapidly; most of the development work has been carried out by research workers in Cambridge University, partly at the Cavendish Laboratory, where the emphasis has been on fundamental studies of dislocations and other defects and on studies of contrast mechanisms, and partly in the Metallurgy Department where the emphasis has been on precipitation and transformation. Much of this work has been supported by D.S.I.R., through grants, for example to Professor Sir Nevill Mott, Dr. F. P. Bowden, Professor A. H. Cottrell and Dr. P. B. Hirsch.

The early experiments showed that it was possible to observe not only the nature and distribution of defects such as dislocations, but also their movement. Special object stages were designed to perform various operations on the specimens in the microscope. Thus a heating stage was built which enabled specimens to be heated to about 1000°C, and a ciné technique was developed for recording the dynamic effects observed.

Of the various methods for thinning specimens to the required thickness of a few thousand Ångstroms, the electro-polishing technique was found to be the most generally applicable. A modification was also developed whereby specimens were thinned from one side only, thus enabling the surface structure and the dislocations inside to be revealed simultaneously. The initial starting material for thinning specimens by the electro-polishing technique is a sheet about 100μ in thickness, and a jet machining method has been developed so enabling such sheets to be prepared from much thicker metal samples without introducing cold work.

The contrasts observed on images of thin metal foils were complex, and the need for a detailed contrast theory became apparent. The observations showed clearly that contrast is produced by local differences in the intensities of the Bragg diffracted beams due to phase differences resulting from displacements of the atoms from their ideal positions in the perfect lattice. Theories have now been developed which explain many of the fine details of contrast observed at stacking faults and dislocations.

The technique has already been applied to many problems; the basic properties of dislocations; for example, glide, interactions, dissociation, nucleation and network formation were studied in stainless steel and other metals, and many of the predicted properties were confirmed in great detail.

Where possible, observations have been correlated with bulk measurements. For example, the density of dislocations in deformed silver, determined by counting, was correlated with flow stress and stored energy measurements. In this way the line energy of a dislocation could be estimated.

Recently the technique has also been applied to study dislocations in non-metallic crystals and both magnesium and graphite have been studied. In addition, thin foil methods have been remarkably successful in the study of precipitation phenomena. The zones which form during the initial stages of the decomposition of a highly supersaturated solid solution have been observed together with the interactions between dislocations and precipitated phases in aluminium alloys and these interactions in internally oxidized materials.

The thin foil methods have also opened an entirely new field in the study of shear transformations. Previously X-ray diffraction and optical metallographic techniques had failed to provide the detailed information required by the phenomenological theories of martensitic transformation. The examination of martensite directly in the electron microscope has provided some of this information.

There is little doubt that the technique has become established as an essential tool for the metallurgist and metal physicist engaged in studies of defects in crystals and no doubt it will be developed further and applied to many problems and materials.

Solid-State Physics

Important achievements in radio-spectroscopy have been taking place. Two aspects of radio-spectroscopy which have been fundamental in advancing our knowledge of the solid state depend on the behaviour of atoms and nuclei in a magnetic field. If an electrically charged particle, not bound in an atom, is placed in a magnetic field, its motion in a plane normal to that field will be circular, with a frequency which depends on the field strength and the ratio (charge/mass) of the particle. If the particle is simultaneously subjected to an oscillating electric field of the same frequency, it can gain energy, as in the cyclotron. This phenomenon, known as cyclotron resonance, can be detected in conducting solids, where it gives information about the interaction between the electrons which carry the electrical current and the atoms of the crystal lattice. Work supported by D.S.I.R. in the Royal Society Mond Laboratory, Cambridge, under Dr. D. Shoenberg and Professor A. B. Pippard, includes measurement of cyclotron resonance in metals, and the resistance of metals at very high frequencies where the electric current flows in a very thin skin (only a few wavelengths of light thick) on the surface; the flow then is modified by the fact that electrons move in and out of this skin without making collisions within it. Associated with this work are observations of the resistance of metals and of the periodic variation of their magnetic susceptibility as a high magnetic field is progressively increased. These various techniques form part of a programme which has yielded very considerable information on the behaviour of electrons in metals.

The second aspect of radio-spectroscopy in solids concerns the motions of electrons and nuclei bound within the atom. All electrons and most nuclei possess magnetic dipole moments which are associated with a spinning motion similar to the rotation of the earth about its own axis. In a magnetic field these atomic magnets precess, in the same way as a top precesses in the gravitational field of the earth. Measurement of the rate of precession gives information about the strength of the internal magnetic field in the solid at the point where the electron or nucleus is fixed in the lattice. The technique of observing the precession, known as magnetic spin resonance, has been extensively used at the Clarendon Laboratory, Oxford, and elsewhere for the study of magnetic materials including paramagnetic, ferromagnetic and antiferromagnetic substances. Most of these substances are insulators, but metals of the transition groups, which have particular magnetic properties, have been studied, as well as cyclotrons resonance in semiconductors.

If the axes about which the nuclear magnets precess can be made parallel to each other, and some of the nuclei are radioactive, then the radioactive emissions (particularly the beta and some gamma rays) are emitted more copiously in some directions than in others. This effect, first successfully demonstrated in the Clarendon Laboratory in 1951, has been used to investigate both nuclear and solid state properties (including the damage caused by radiation in an atomic pile). In order to align the nuclear magnets, which normally point in random directions because of thermal agitation, special methods must be used to cool substances containing them to about one thousandth of a degree Centigrade above absolute zero. These techniques employ magnetic cooling, using electronic magnetic moments, but more recently (1956) a similar method using nuclear magnets only has been developed to reach temperatures of one millionth of a degree absolute.

The common feature of nearly all these experiments has been the need for large magnetic fields. For the resonance experiments medium-sized magnets suffice, but the fields must be uniform and stable to a high degree. Grants from D.S.I.R. have been used to provide such magnets, together with the associated electronic equipment for generation and detection of the microwave radiation. Much higher fields are needed for the study of metals and for magnetic cooling, though here uniformity and stabilization are not so essential, and in 1959, D.S.I.R. research grants were given to Professor A. B. Pippard at Cambridge

University and Dr. N. Kurti at Oxford University for the provision of magnetic fields in the 100 kG range for use in the study of metals and the properties of substances in the magnetic cooling range respectively.

One of the most difficult regions for spectroscopy is the far infra-red (wavelengths between 1 mm and 1/10th mm). The power emitted by sources in this region is very low, and until recently no sensitive detectors had been available. Supported by a D.S.I.R. grant, a group at Queen Mary College, London, under Professor G. O. Jones has developed for this region a super-conducting bolometer which has very high sensitivity. This has been used for work on the lattice vibrations of simple crystals. Other work at Queen Mary College supported by D.S.I.R. includes measurement of the properties of the solidified inert gases (particularly argon); these are of interest from the theoretical point of view, since they form a particularly simple class of solids.

Radiation Effects in Crystals

The interest in the study of radiation damage in solids is twofold. In one case radiation is used as a controllable method of introducing defects for determining their properties, while in the other case the interest is in the amount of damage produced by given types of incident particles.

In all experiments an important quantity is the minimum recoil energy E_d which is required to displace an atom. It is found that for many materials these energies are in the range 10–100 eV. This is conveniently matched by the recoil energies which are obtained when irradiating with electrons of energy up to 2 MeV.

Irradiation with practical sources of heavier particles (e.g. neutrons and deuterons) leads to recoil energies of up to about 10^5 eV, the struck atom itself then producing a lot more damage. This complication is avoided when irradiation by electron energy is used.

In order to determine E_d the rate of change of a physical property is measured as a function of the energy of the bombarding electron. These results are compared with the shapes of a family of theoretical curves which can be calculated for different assumed values of E_d.

Such experiments, on several materials, have been made in the Physics Department, Reading University, under Profressor R. W. Ditchburn. Using the changes induced in the optical absorption spectra of diamonds, and also of the resistivity changes in p-type semiconducting diamonds, a value of E_d 80 eV has been estimated for a carbon atom of diamond. Precise agreement between the two methods is not obtained however. Similar investigations of the damage produced by electrons in the following materials are in progress:

(i) Graphite—using changes in electrical resistivity.
(ii) Aluminium oxide—using optical absorption and emission techniques.
(iii) Copper—using changes in internal friction produced by the pinning of dislocations by defects.

In determining the theoretical rates of production of defects during electron irradiation, it is necessary to make due allowance for the concentration gradient of defects produced. The most reliable calculations are those which are based upon experimentally determined range-energy expressions. Available information of this sort is restricted to a very few materials at present.

Detailed information about the defects produced by irradiation is revealed by investigating the kinetics of the processes which occur during subsequent thermal annealing. For instance, optical absorption measurements during thermal annealing indicate that several independent annealing processes are involved. The proportions of the defects which anneal in the different processes are dependent upon the temperature at which the irradiations were carried out. Such results emphasize the importance of carrying out all irradiations at the lowest possible temperatures. The results also suggest that all interstitial vacancy sites are not equivalent, i.e. that interstitials produced close to the resulting vacant atomic sites have a lower activation energy for recombination than those pairs which are widely separated.

Effects due to the redistribution of electrons caused by irradiation are frequently observed. For example:

(i) In semiconductors compensation of acceptor levels results from the introduction of a smaller number of donor centres.

(ii) The smoky colouration produced in quartz is thought to be due to the trapping of holes on oxygen ions adjacent to aluminium impurity atoms.

(iii) Electrons trapped at unoccupied cation sites in the alkali halides give rise to the well known F-band absorption.

Imperfections resulting from the aggregation of point defects induced by radiation damage have been observed directly in the electron microscope by research workers at Cambridge. Individual point defects have not been observed directly. Nevertheless, studies of the optical anisotropies associated with defects can give information about the electronic symmetry of the centres, from which the position of the defect in the lattice may sometimes be inferred. Examples of these measurements are:

(i) The anisotropic optical absorption studies of bands in electron and neutron-irradiated sapphire.

(ii) The study of the polarization of luminescence excited by plane polarized light in centres produced in diamond by irradiation and subsequent heat treatment.

Absorption in the infra-red associated with the creation of single phonons has been observed in diamonds irradiated by fast neutrons. This absorption is forbidden in the perfect lattice but becomes allowed because the presence of defects or impurities creates localised dipoles in the lattice and gives rise to a coupling between the radiation field and the lattice vibrations. Because the damage produced by neutrons is more complicated than that produced by electrons, it is not clear to what extent the effect is due to point defects. Studies of this effect in heavily electron-irradiated diamonds should resolve this problem.

Projection X-ray Microscope and Scanning Microanalyser

The projection X-ray microscope was first built at the Cavendish Laboratory, Cambridge, in the early 1950's and was later developed with the aid of a D.S.I.R. grant awarded to Dr. V. E. Cosslett. Under this grant workers in the University have explored some of its applications in metallurgy, botany and zoology and in addition a method of element microanalysis based on differential absorption of X-rays has been developed. It has been applied in particular to the study of the distribution of calcium in teeth and in certain minerals; and more recently the advantages of the projection X-ray tube for microdiffraction have been exploited for studying the effects of mechanical stress in beryllium.

The scanning microanalyser, which is a form of X-ray spectrometer for displaying an image of the region of a surface being analysed, was devised at the Cavendish Laboratory and built by a postgraduate student on a D.S.I.R. maintenance grant during 1953–56. The development of the instrument was continued and its applications to metallurgical work explored. An improved model has since been designed at Cambridge and is now commercially produced by the Cambridge Instrument Company under the name of Microscan. It is proving of great value for microanalysis of metallurgical samples, especially complex alloys and diffusion couples. A variant of the microanalyser has been designed for mineralogical investigations, and it is now being improved and its applications to research problems explored in the department of Mineralogy and Petrology, Cambridge, with the aid of another grant. The possible biological applications of the instrument are being investigated with still another model built in the Cavendish Laboratory.

NUCLEAR PHYSICS

Number and Value of Grants Awarded

1956/57 (Oct–Sept)		1957/58 (Oct–Sept)		1958/59 (Oct–Sept)		1959/60 (Oct–Sept)	
No.	Value	No.	Value	No.	Value	No.	Value
22	£456 946	36	£604 286	52	£826 501	42	£767 375

Nuclear Physics Research 1945–60

The development of nuclear physics research in British universities since 1945 has demanded financial support very different, both in scale and in character, from that needed in other fields of university science. The proposed research programme in the early post-war years was a logical outcome of the advances made in nuclear physics during 1939–45, and the first five years saw the initiation of substantial Government grants towards the construction of large particle accelerators as the basic tools for nuclear physics research in the universities. A period of consolidation followed, but more recently the need for higher energies has led to the construction of even larger particle accelerating machines at centres such as C.E.R.N. (the European Organization for Nuclear Research at Geneva) and N.I.R.N.S. (the National Institute for Research in Nuclear Science centred on the Rutherford Laboratory at Harwell), with consequent opportunities for universities to extend their programmes by sharing in the use of these expensive facilities. Although many of the major centres of nuclear physics research in universities have developed around the "big machines", other important advances have been made without the use of particle accelerators, an example being the large amount of work carried out on cosmic radiation, some of it on mountain tops and with balloons. The development of techniques for studying high-energy particle reactions has also played a notable part in the advances made in nuclear physics.

The Early Post-War Years

The end of World War II presented this country with a band of skilled nuclear physicists, but few facilities, other than those which could be made available by

Government establishments, for the prosecution of university research in nuclear physics. The field which had been opened by the work carried out under the atomic energy programme during the war was highly promising, and it was obvious that the programmes which the universities wished to carry out would lead to a very much higher and more expensive level of activity than there was before the war. However, little new equipment had been provided during the war and the money required for the construction and maintenance of large particle accelerators was undoubtedly beyond the means of the universities, but the Government agreed to support through D.S.I.R. nuclear physics research at the universities.

The early post-war years saw the establishment of a Nuclear Physics Committee (responsible to the Minister of Supply) "to promote nuclear physics in universities; and to advise on Government grants to universities for research in nuclear physics having regard to the programmes in Government establishments". The grants were, however, made by D.S.I.R. on the advice of the Nuclear Physics Committee. The centres initially concerned were Birmingham, Bristol, Cambridge, Edinburgh, Glasgow, Liverpool, London (Imperial College and King's College), Manchester, and Oxford, but some universities developed their work in other directions and the construction of the large particle accelerators ultimately centred on Birmingham, Cambridge, Glasgow, Liverpool and Oxford. The work of the Nuclear Physics Committee was primarily concerned with the construction of the machines which were being provided at these centres; other programmes in nuclear physics, of which there were several, were supported by D.S.I.R. on the advice of its former Scientific Grants Committee.

The purpose for which the Nuclear Physics Committee of the Ministry of Supply had been set up was largely fulfilled by the end of 1951, when the programmes in the individual universities were well under way. The Committee was then disbanded and a new D.S.I.R. Committee constituted in its place.

1952–57

The new Nuclear Physics Committee of the D.S.I.R. Advisory Council was concerned only with the programmes for the high-energy particle accelerators and directly related research, and its work was complementary to that of the Scientific Grants Committee. Since 1956, when the Research Council replaced the Advisory Council, grants for nuclear physics research have been dealt with by the Nuclear Physics Sub-committee of the Research Grants Committee (R.G.C.) the latter having replaced the Scientific Grants Committee.

The start of the university quinquennium 1952–57 led to new arrangements for the financing of nuclear physics research. The universities felt that the position was not sufficiently stable for realistic forecasts of expenditure over the quinquennium to be made and that it was still necessary to consider separately the special needs of nuclear physics. Discussions with the U.G.C. and with the universities led to agreement that D.S.I.R. should continue to receive applications for grants during the 1952–57 quinquennium, not only for non-recurrent capital charges, but also for the recurrent expenses of operating the high-energy particle accelerators, which were considered to be disproportionately heavy in relation to the universities' total resources for research. The basis of the arrangement made at that time was that the five universities would continue to make such provision as they could out of their general resources, including the U.G.C. block grant, for nuclear physics, but could apply to

D.S.I.R. for special research grants to supplement these resources, particularly where, as a result of large new commitments, recurrent expenditure had become disproportionate to that of other departments. The five centres therefore continued to receive quinquennial grants from D.S.I.R. covering both the provision of new equipment and the running and maintenance costs of the existing equipment.

The quinquennium also saw a considerable enlargement of the programmes at other centres, particularly Bristol University, Durham University, Leeds University, Manchester University, and Imperial College and University College, London. These groups were not only using the facilities outside their own departments, but were also developing substantial independent programmes in fields such as cosmic radiation.

The end of the quinquennium saw large-scale programmes in nuclear physics in full progress, but the existing machines had still to reach their maximum usefulness as research tools and running costs were still sufficiently high, and liable to fluctuations, particularly in the event of major replacements being necessary, to make it difficult for the universities to provide for them solely through their quinquennial support from the U.G.C. It was then agreed that for the following quinquennium, 1957–62, the universities should provide for the maintenance and running costs of the smaller equipment, while certain approved machines would qualify for what were virtually maintenance grants from D.S.I.R., although this was an unusual arrangement under the D.S.I.R. scheme.

Maintenance Grants

Maintenance grants have been awarded annually throughout the current quinquennium for the Birmingham proton-synchrotron, Cambridge Van de Graaff, Glasgow synchrotron, Liverpool synchro-cyclotron and Oxford synchrotron. These grants have been confined to the support needed—according to a formula known as the "Hale" formula—for normal maintenance of the machines, and the provision of technicians and the cost of electric power, coolants and refrigerants required for the production of a beam of particles. The cost of the research using the beams has been a university responsibility, although special research grants have continued to be awarded in support of particular programmes.

Important programmes have been and are still being carried out with these machines. The work with three of them, Liverpool, Birmingham and Glasgow, is described in some detail.

The University of Liverpool 400 *MeV Synchrocyclotron*

This machine is one of three large particle accelerator projects at Liverpool University supported by D.S.I.R. since the war. It was initiated by Professor (now Sir James) Chadwick and delivery and installation were completed in December 1954 under the supervision of the late Professor Skinner, who succeeded Professor Chadwick at Liverpool in 1949. The cyclotron has been an extremely successful machine technically. It has been operated 14 hours a day, 6 days a week, with a weekday shutdown for maintenance. A record of more than 90 per cent of availability for experimental purposes has been consistently maintained from early 1955 onwards.

An external proton beam of extremely high intensity was extracted in 1955 by a new method developed at Liverpool by Le Couteur and Crewe. Use of this beam has, however, been limited so far by "duty cycle" difficulties, and most of the research has in fact been done with pion and muon beams. A neutron beam has also been available.

Four teams from the Physics Department, one operating particle counters and one visual detectors, have been maintained at the machine, each group consisting of two academic members of staff, one fellow, and three postgraduate students. A large number of outside institutions have also made use of the machine. Photographic emulsions have been exposed for the Universities of Cambridge, Bristol, Durham, Glasgow, Rome and others; a cloud chamber has been operated at the machine by the University of Edinburgh; and counter experiments have been done by A.E.R.E., Harwell, and by the University of Manchester. The A.E.R.E. contribution by West and his collaborators is particularly noteworthy as the best work so far available on mesonic X-rays. Some examples of the work of the Liverpool University group may be quoted, to show the range and significance of the research programme.

An early experiment was done to investigate the fate of negative pions stopped in liquid hydrogen. Capture of the negative pions by protons may produce neutral pions or hard γ-radiation. The ratio of the probabilities for these two processes is a number which acts as a link between pion-proton scattering and pion photoproduction, two processes which are studied in quite different laboratories, since the first requires a proton accelerator and the second an electron accelerator. A puzzling factor of discrepancy of two in the link between them was removed as a result of the Liverpool work.

A large group of experiments was stimulated by the discovery that "parity" was not conserved in certain particle decay processes. This fact was immediately exploited in a determination of the muon's magnetic moment, which reduced the uncertainty in this quantity from 10 per cent to a fraction of 1 per cent though this degree of accuracy was in turn overtaken a few months later by further experiments in the U.S.A.

Perhaps the most exciting experiment was a determination at Liverpool of the sense of rotation of the spins of the high-energy electrons emitted in muon decay. A rather simple argument makes it possible to infer whether the spin and momentum of the neutrino are related like the thread and axis of a right or left-handed screw. Contrary to expectation, the Liverpool experiment showed that the left-handed arrangement was the correct one. This result was one of several which stimulated a searching re-examination of the beta-decay process in nuclei, which previously had suggested a right-handed neutrino. Another Liverpool experiment relevant to the same problem showed that pions only extremely rarely decay into electrons accompanied by neutrinos and γ-radiation. Such a process was predicted by the then current theory of beta decay. Eventually, in the U.S.A., an error was discovered in one of the fundamental beta-ray experiments (the angular correlation of electrons and neutrinos in He^6 decay). Rectification of the error put the theory of these decay processes into its present rather tidy state, a very satisfactory situation sealed by the pion-electron decay experiment at C.E.R.N.

A Liverpool experiment in quite a different field may be mentioned in which the γ-radiation emitted in catalysed muon fusion was detected for the first, and indeed only, time. A negative muon stopped in natural liquid hydrogen can form a molecule in which a proton and a deuteron are bound. The dimensions of the molecule are smaller than usual by a factor of 200 because of the large mass of the muon as compared with an electron. The nuclear particles are in fact drawn so close together that fusion can take place, with the emission of γ-radiation and production of helium. Unfortunately this process is unsuitable for commercial application in the production of power, but only by a very few orders of magnitude.

Much quantitative work on the details of the strong interactions between nucleons and pions has been omitted from this necessarily brief survey. Much patient work of this kind is foreseen for at least a decade ahead, and alterations to the technical performance of the synchrocyclotron to aid it are now being undertaken. Possibly the days of its most exciting discoveries are past, but the synchrocyclotron is still a most useful machine in 1961.

The whole research programme has been most fruitful as a training ground for postgraduate students, most of whom have been supported by D.S.I.R. A considerable number are now to be found in other high-energy laboratories, particularly in C.E.R.N. However, a majority have turned to other work on leaving Liverpool. More than half are now working for the U.K.A.E.A. on applied physics and development engineering, and it is interesting to note that high-energy physics, an "abstract" science, produces a type of man so valuable to our national economy.

The University of Birmingham 1000 MeV Proton Synchrotron

The Birmingham proton synchrotron was the first machine of its kind to be designed, and the second to be completed (July, 1953). It was rehoused in 1958 and at about the same time a hydrogen liquefier was provided by D.S.I.R. Thus, after five years of limitation to beam intensities suitable only for emulsion and track-chamber work, the synchrotron became available for counter experiments with liquid hydrogen targets. In 1960 a deuteron beam was accelerated and extracted. The synchrotron has thus become a flexible experimental unit, with protons and deuterons (and, by charge-exchange, neutrons) available at energies 50 per cent above those obtainable from any cyclotron and with intensities sufficient for refined experiments on nucleon-nucleon collisions.

The following summaries of experimental work are divided into two periods: nuclear emulsion and cloud chamber studies prior to the reorganization of the laboratory in 1958–9; and bubble chamber and particle counter experiments in the last three years. In the earlier period two researches deserve special mention; the observation of substantial polarization in protons scattered at small angles from carbon at energies as high as 1000 MeV, and the p-p and p-d interactions studied by the cloud chamber method.

The first polarization experiments were performed with carbon as the second scatterer and nuclear emulsion as the detector. Lack of energy-resolution was a severe handicap but this has been largely overcome by the development of Cerenkov counters; however, polarization studies in nucleon-nucleon collisions at about 1 GeV still represent a challenge.

The importance of the work on proton-proton and proton-deuteron interaction was twofold. In these experiments the charged particles (including pions) emerging from the collisions are identifiable and their energies directly measureable, but information may also be deduced about neutrons and neutral pions that may have been formed. The first point of note is that, to a good approximation, the pd collisions are effectively *pn* or *pp* collisions, the other nucleon (*p* or *n* respectively) of the target deuteron being virtually a spectator. The second point, appreciated recently by theoretical physicists and finding its experimental backing in the Birmingham results on energy distribution of the neutrons from the reaction $p+p=p+n+\pi^+$, is that this basic reaction may be regarded as the collision of the incoming proton with a pion virtually existing in the target proton.

Another experiment of interest was the determination of the momentum distribution of nucleons in carbon by analysis of proton-carbon collisions observed in a small propane-filled bubble chamber. This work showed that information about atomic nuclei in their "ground" state may sometimes be obtained from experiments in the GeV range.

The work carried out since 1958 has included the use of counters and the extracted beam at 1010 MeV to compare the yields of protons at 90° in the centre-of-mass system from *p-p* and *p-n* collisions (the neutrons being in deuterium) and to measure the *p-p* distribution from 18½° to 90°. The results obtained are consistent with the hypothesis of charge-independence of nuclear forces.

A series of scattering asymmetry experiments, carried out with 970 MeV polarized protons from a target internal to the machine, has shown a maximum of polarization of about 40 per cent at an angle of about 48° (centre of mass). Although there appears to be no simple theory of polarization phenomena, an analysis of the Birmingham results in terms of partial waves shows that high angular momenta, including F waves, must be involved.

The nine-inch bubble chamber, built as the successor to the diffusion cloud-chamber and operable with either hydrogen or deuterium, is being used for studies of *np* and *nd* collisions with charge-exchange neutrons, with a *d-d* programme in prospect.

The present programme with the synchrotron has been greatly influenced by the success of the deuteron beam, which at 650 MeV gives the highest energy that is known to be available in any laboratory. Much interest lies in the deuteron-deuteron interaction, in which a resonance between two pions may be expected according to recent proton-deuteron work at Berkeley. The Birmingham group is also extending *p-d* work to a higher energy than that of the Berkeley synchrocyclotron, a programme which typifies the role of this machine for nucleon experiments of "synchrocyclotron" type at a higher energy.

The University of Glasgow Electron Synchrotron

The construction of the Glasgow electron synchrotron was completed during the summer of 1953 and a circulating beam of electrons at low magnetic field was first observed in November, 1953. The energy was gradually raised to a maximum and a 340 Mev beam of photons was first achieved in April, 1954. Many modifications and correction circuits were added to effect improvement in output, and by the end of 1954 a collimated output of 10^7 equivalent quanta per pulse ($\sim 2 \times 10^9$ per minute) was available for experiments in photodisintegration and meson physics. Facilities for production of pulses of time-width up to 1·5 msec or for short pulses of duration 0·5 μsec have been provided. During 1960 a d.c. biassing system was added to the power supplies. This makes possible the extension of the output photon energy to 450 MeV.

The research programme utilizing this machine falls into two main divisions: work upon photoproduction of mesons and work upon nuclear photodisintegration.

Photoproduction of Mesons

The two basic processes for the production of charged mesons are (i) $\gamma+p\longrightarrow\pi^++n$ and (ii) $\gamma+n\longrightarrow\pi^-+p$. The first process can be studied directly with a hydrogen target but the second must be done indirectly by observing π^- production from nuclei. For this purpose deuterium is normally used, since it is the nearest approximation to a free neutron target which can be obtained.

(i) *Photoproduction from Hydrogen.* The work on the first reaction has been directed mainly to measurements of the cross-section at γ-ray energies near to the threshold energy (152 MeV). These measurements, which are experimentally very difficult because of the small cross-sections and low pion energies involved, are of considerable theoretical interest, since they can lead to a determination of the pion-nucleon coupling constant and can also be correlated, by considerations of detailed balancing, with data on pion scattering, absorption and negative pion photoproduction. The results reported from Glasgow played a considerable part in resolving discrepancies in this correlation. The results of extensive series of measurements by two different techniques were in satisfactory agreement with each other and clearly showed a rise towards threshold, as predicted by dispersion relation theory, which had not been satisfactorily demonstrated by previous experimental results. The absolute agreement with dispersion relation predictions based on a pion-nucleon coupling constant $f^2=0\cdot08$ is also very satisfactory.

(ii) *Photoproduction from Deuterium.* The quantity which is normally measured in experiments on the photoproduction of pions from deuterium is the ratio $\frac{\sigma -}{\sigma +}$ of the cross-sections for negative and positive pion production. Again, two different experimental techniques have been used, one employing a magnetic spectrometer and the other scintillation detectors. The first technique yielded a value of $\frac{\sigma -}{\sigma +}=1\cdot6$ at threshold, which after application of Coulomb corrections is in agreement with the theoretical prediction for free nucleons. The second technique gave substantially the same result even though the observational angular range, in laboratory co-ordinates, was different.

Work has also been done upon the photoproduction of neutral pions from hydrogen and deuterium. These studies bear upon the relevance of charge independence and impulse approximations. Cross-sections were measured by observations on recoil protons using time of flight techniques.

In addition to the primary processes of photoproduction at nucleons referred to above, work has been carried out upon meson photoproduction in more complex nuclei. Thus the study of π° photoproduction in helium provides an opportunity to compare experimental results with theoretical predictions based upon the above-mentioned elementary processes and to look for evidence of the existence of non-linear effects. The reaction $He^4(\gamma\ \pi^\circ)He^4$ was therefore carefully studied using $\frac{dE}{dx}\Big/E$ counter telescopes to detect He^4 recoils separately from the He^3 particles produced by the reaction $He^4(\gamma,n)He^3$. The results showed agreement with calculations based on the impulse approximation.

The whole of the work described above has utilized counter techniques for particle detection but more recently bubble chamber methods have been developed for such studies. One interesting technique in this field employs a large propane chamber with an internal target of high-pressure gas, enclosed within a thin-walled tube which passes along a diameter of the chamber. This instrument has been used to investigate the reactions $\gamma + p \longrightarrow n + \pi^+$ and $\gamma + p \longrightarrow p + \pi^+$ over a range of energies and angles. The analysis of the results of this experiment is now almost complete. A second experiment concerned with the reactions $\gamma + D \longrightarrow \pi^+ + n + n$ and $\gamma + D \longrightarrow \pi^- + p + p$ and associated reactions in deuterium is being carried out at present using the same technique.

Nuclear Photodisintegration

The first investigations on photodisintegration were an extension and completion of cloud chamber studies on light elements, particularly nitrogen and oxygen, which had been begun with the 30 MeV synchrotron. Important conclusions were reached concerning the excited states involved in the quantum absorption and the competition between different modes of de-excitation, by particle emission, at energies below and through the giant resonance. The 300 MeV synchrotron bremsstrahlung beam permitted the extension of these studies into a region of higher energy. This extension is significant in that the nature of the process is then basically changed. Thus at lower energies, where the quantum wavelength is large compared to nuclear dimension, the energy absorbed is shared by all the nuclear components, whilst at higher energies, where the quantum wavelength is less than the nuclear diameter, energy can be imparted to a limited region of the nucleus. The state of the whole nucleus is no longer involved. The state of a limited number of the component nucleons, usually no more than two, now governs the conditions for absorption.

This consideration leads to the prediction that at higher quantum energies photodisintegration should result in the simultaneous emission of a high-energy proton and neutron. Experiments with scintillation telescopes in America suggested that such a process did take place. This finding has been confirmed by the Glasgow work and knowledge of the process has been extended by studies of the high-energy disintegration of nitrogen and oxygen in a counter-controlled cloud chamber. By this technique it was also found that the residual nucleus, following the departure of the neutron-proton pair, subsequently disintegrates on many more occasions than can be explained by chance collisions of one of the energetic particles on its way out from the nucleus. From the kinematics of these reactions it was also possible to measure the internal momentum of the proton-neutron pair within the nucleus at the moment of quantum absorption. This internal momentum distribution, together with knowledge of the final state of excitation of the residual nucleus, provides valuable experimental material against which theories of the constitution of nuclear matter can be tested.

The European Organization for Nuclear Research (C.E.R.N.)

In the early 1950s several Western European countries realized that owing to the great cost of the capital facilities required, few, if any, of them could afford individually to equip laboratories with the very large, high-energy machines which were becoming essential for the advancement of nuclear physics research. The European Organization for Nuclear Research (C.E.R.N.) was therefore set up under an Inter-Governmental Convention which came into force in 1954, to provide, in the words of the Convention, "for collaboration among European States in nuclear research of a pure scientific and fundamental character and in research essentially related thereto. The Organization shall have no concern with work for military requirements, and the results of its experimental and theoretical work shall be published or otherwise made generally available". There are at present fourteen members of C.E.R.N. including the United Kingdom, and the laboratory of the organization is in Switzerland, near Geneva.

In the initial years C.E.R.N.'s major expenditure was on buildings and apparatus, especially the two large accelerators and their associated facilities for research. The smaller accelerator (a synchrocyclotron), capable of accelerating protons up to about 600 MeV, has been in commission for five years. The larger machine (a proton synchrotron) for energies up to 25 GeV, has been in operation for nearly three years and at well above its designed energy. The cost of C.E.R.N. is shared by member states in proportion to their national income. D.S.I.R. is the responsible Government department for the United Kingdom membership of C.E.R.N. and bears on its vote the United Kingdom subscription (which was £1·36 m. in 1960).

The universities have directly benefited from the U.K. membership of C.E.R.N. and full use has been made of the facilities available. These have enabled universities to carry out a range of experiments which could not have been undertaken elsewhere. Time on the synchrocyclotron has been allocated to member states, and university "truck" teams have visited Geneva for individual experiments on the machine. These teams have been eligible for support through special research grants to meet the costs of particular programmes. However, the pattern in C.E.R.N. is now changing in favour of experiments by mixed national teams, and universities are participating fully in the programmes for both emulsion experiments and track-chamber experiments. A major contribution to the latter is being made by the United Kingdom through the British National Hydrogen Bubble-Chamber project. This is referred to more fully later.

The National Institute for Research in Nuclear Science (N.I.R.N.S.)

In the same way that C.E.R.N. has provided facilities beyond the resources of any one country, the N.I.R.N.S. was set up in 1957 *inter alia* "to provide, equip and operate, for common use by universities and by other institutions and persons engaged in research in nuclear and related matters, facilities which by reason of their size or cost or otherwise howsoever are beyond the scope of individual universities, institutions or persons as aforesaid" and "to permit and encourage scientists of universities, colleges and the United Kingdom Atomic Energy Authority and other institutions, as well as scientists of industrial laboratories, to make such use of facilities provided as aforesaid as the Institute may determine to be appropriate". A 50 MeV proton linear accelerator is already in operation at the Institute's Rutherford High Energy Laboratory at Harwell and a 7 GeV proton synchrotron ("Nimrod") is under construction. These facilities are complementary to those provided by C.E.R.N. and to the support provided by D.S.I.R. through special research grants.

Universities have shown a keen interest in participating in the research programmes using the proton linear accelerator. The policy agreed by the Institute, D.S.I.R. and the U.G.C. regarding the financing of these experiments is broadly that the Institute bears the whole cost with the exception of the salaries of those members of the visiting teams from universities who are graduate research staff. The latter is a university responsibility but support for such staff can be sought through special research grants from D.S.I.R.

Current Support by D.S.I.R. for Nuclear Physics Research

The R.G.C., on the advice of its Nuclear Physics Sub-Committee, now supports a wide range of nuclear physics research by universities. This includes the provision of capital facilities (for example new particle accelerating machines, provided that these are within the scope of individual universities and not projects of the type for which N.I.R.N.S. was set up, and also capital facilities required for use with beams of particles), "maintenance" grants for existing machines, support for programmes at C.E.R.N. and N.I.R.N.S., and support for a large number of other programmes undertaken by universities, both within and outside their own departments, and carried out not only by individual groups but often by an association of groups from different departments and institutions.

The work on cosmic radiation, in which Bristol University has played a notable part, is illustrative of the kind of support which D.S.I.R. has given through special research grants.

Work on Cosmic Radiation (Professor C. F. Powell)

The work on cosmic radiation in Great Britain has now been supported by D.S.I.R. for fifteen years. Immediately after the war, in the period 1946–1953, the work was particularly fruitful in leading to the discovery of several new elementary particles and some of their fundamental properties. The π-meson was discovered in 1947 using the new emulsion technique at Bristol, and in the same year cloud chamber experiments at Manchester gave conclusive evidence of neutral particles heavier than the π-meson. Up to about 1953 the emulsion and cloud chamber techniques were used very successfully by several British groups. Emulsions were exposed at mountain and balloon altitudes and cloud chambers were set up on the Pic-du-Midi in the French Pyrenees and on the Jungfraujoch in Switzerland. The high-energy nucleon component of the cosmic-ray beam at these altitudes interacted in the emulsions or in heavy material above and inside cloud chambers. New particles, both mesons and hyperons, were identified from the nucleon interactions and a number of their properties, for example decay modes, masses and lifetimes, were determined. More than half the elementary particles now known were discovered in experiments with cosmic radiation. Apart from their great intrinsic interest these discoveries played an important part in stimulating the design and construction of the great new accelerators with which the properties of the particles could be studied in detail under controlled conditions in the laboratory.

As the accelerators came into operation, the principle field of interest at Bristol University changed and two aspects of the work came into prominence. First, the study of the composition of the fast nuclei which constitute the primary cosmic radiation and the distribution in energy of these particles; such studies are of central importance for investigating the origin of the cosmic radiation and the processes in interstellar space whereby they are given their great energies. Secondly, the study of nuclear interactions produced by particles with energies much greater than can be generated artificially in the accelerators. At the present time, the most powerful proton synchrotons produce particles with energies of 30 GeV. Individual particles with an energy 10^5 times greater than this value occur in cosmic radiation sufficiently frequently to allow a detailed study of the results of their collision with nuclei.

These experiments have led to a detailed knowledge of the nature of the primary cosmic radiation and to the advancement of theories for its origin. The progress of the subject has thus been greatly advanced. A point of great interest and importance is that the work on cosmic radiation becomes intimately related to theories of stellar evolution and to studies with radio-astronomy of the tenuous ionized gas in interstellar space.

The studies of high-energy collisions have now established some of the most important features of the nuclear interactions of protons in the energy interval from 100 GeV to 10^5 GeV. The most important facts which have been established are that the cross-section for the interactions depart very little, if at all, from the "geometrical value" found at lower energies; that the same particles, produced at accelerator energies (30 GeV), and no new ones, are created in the collisions of particles with energy up to 10^5 GeV; that most of the secondary particles are π-mesons (75 per cent); and that the collisions are relatively elastic, only about half the available energy being carried off by the particles created in the interaction. These studies are also important in contributing to the important discussion of the desirability of the construction of much greater accelerators by giving an indication of the nature and extent of the new knowledge which they might make accessible.

These studies at Bristol University have demanded the development of methods of manufacturing large stacks of photographic emulsion (up to 40 litres) and their successful processing without distortion; and the construction of large balloons (Plate 1) capable of carrying loads of ½ ton to altitudes above 100 000 ft. The balloon experiments have also required the development of methods of launching heavy loads and of overcoming the difficulties of maintaining level flights at high altitudes over long periods. As a result of this work Bristol University is the only centre in Europe which has the capacity to undertake operations of this kind. This capacity has been of great importance for the support of cosmic-ray experiments in Europe and for the training of personnel skilled in many novel types of operation and has also established for Bristol University a leading part in international programmes. At present high-altitude flights are being made from Southern Italy and these will provide experimental material for a large number of European laboratories. The successful solution of all these problems could not have been reached without the substantial support provided by D.S.I.R. over the years. It has ensured for this country a leading place in the physics of cosmic radiation and of nuclear interactions in the region of extremely high energies.

Experiments on Large Cosmic-Ray Showers

A new programme of particular interest is that being carried out under the direction of Professor J. G. Wilson of Leeds University on large cosmic-ray showers. This is a long-term project for the measurement of the size-spectrum and time relations of very large cosmic-ray showers incident near sea-level, and the relation of these measurements to the spectrum of the primary particles falling on the earth. The work is being undertaken collaboratively by Leeds and Durham Universities and Imperial College, London, and the measurements will be made over a wide area at Havarah Park, near Harrogate.

The co-operation between groups from different universities has been a notable feature of the development of nuclear physics research in recent years. Arrangements have been made to share capital facilities and several projects have been undertaken by consortia of universities *ab initio*. The British National Hydrogen Bubble Chamber project and the National Film Analysis Equipment programme provide well-known examples of the latter.

The British National Hydrogen Bubble Chamber

The most valuable experimental techniques for use with large particle accelerators are those which enable the actual paths, or tracks, of the particles to be photographed. Three techniques of this kind are now available, all depending on the fact that when a charged particle traverses matter the atoms along its path become ionized. The first is the cloud chamber, devised some fifty years ago, in which droplets are condensed on the gaseous ions and then photographed; this technique has been used extensively in cosmic-ray physics but it has several serious disadvantages for use with large particle accelerators. The second technique uses special photographic emulsions, which are exposed to beams of particles produced by the accelerator. The third, and now the most important, visual technique was discovered in 1952 by D. A. Glaser, who showed that a trail of vapour bubbles can be formed when a charged particle passes through a superheated liquid: in effect the liquid boils along the line of ions. Glaser rapidly proved that this new technique had very important advantages over the cloud chamber and emulsion techniques, and it was soon realised that liquid hydrogen was the ideal liquid to use in these "bubble chambers" because it consists solely of protons.

In 1957 a working party drawn from Birmingham, Liverpool, London and Oxford Universities, with representation from A.E.R.E., Harwell, was formed to discuss plans for a 150 cm British hydrogen bubble chamber for use with the C.E.R.N. 25 GeV proton synchrotron and the N.I.R.N.S. 7 GeV proton synchrotron. A grant in support of the programme was announced by D.S.I.R. early in 1958 and work on the chamber began immediately.

The construction of the chamber has been a truly collaborative effort between Imperial College, London, and Birmingham and Liverpool Universities. The greater part of the components have been manufactured under contract, but the design and model work has been carried out almost exclusively by the university groups concerned. The main parts of the apparatus are: (i) the chamber vessel itself, in forged aluminium alloy and fitted with two vertical glass windows, which has been designed in detail by the Liverpool group; (ii) the expansion system for the chamber, also designed by the Liverpool group; (iii) the hydrogen shield, used to contain the liquid hydrogen if a leak or fracture of a window should occur; (iv) the liquid nitrogen shield, used to screen the vessel from extraneous heat; (v) the vacuum tank, with associated pumping equipment, which encloses the above, and which has also been designed by the Liverpool group; (vi) the hydrogen liquefier; (vii) the electromagnet (Plate 6), weighing over 300 tons including the coils, for which the design and model work has been carried out by the Birmingham group; (viii) the optical and photographic system, for recording the particle tracks, which has been designed in detail by a group at Imperial College, London; and (ix) the control arrangements for the whole apparatus, which have also been designed by Imperial College. The whole programme has required detailed organization and control, particularly as the contracts for some of the main components have had to be let in several parts, and the smoothness and precision with which it has progressed is testimony to the work of the Management Committee, under the Chairmanship of Professor C. C. Butler, and to the collaboration between the individual groups concerned. The assembly and testing of the various components is now proceeding at the Rutherford High Energy Laboratory with assistance from N.I.R.N.S.

Experiments with the British National Hydrogen Bubble Chamber

The British liquid hydrogen bubble chamber will be operated initially with the C.E.R.N. 25 GeV proton synchrotron. Shipment of the chamber to Geneva commenced in the autumn of 1961 and it is expected that it will begin operation early in 1963. A further grant has been made by D.S.I.R. for the operation of the chamber at C.E.R.N., following which it will return for use with the N.I.R.N.S. 7 GeV proton synchrotron ("Nimrod").

In the actual operation of the chamber the particle tracks will be photographed simultaneously by three separate cameras, giving a stereo-record of the event. The entire operation, from the expansion of the chamber, lasts about 1/50th second for each event, and it should be possible to photograph ten to twenty events per minute. It is expected that in a year's working of the chamber (about fifty days' actual operation) some four or five experiments or runs of about 250 000 pictures each will be made.

Exposures with pion and proton beams of high energy will be made to calibrate the chamber and also to study production processes for strange particles and π – mesons. The main, and most important, experiments will be on beams of antiprotons, and K-mesons of 3 GeV/c and higher momenta. Initially these will be produced in internal targets and transported over 150 m to the chamber. Later, an external proton beam may be used with a target which will enable K-meson beams of less than 3 GeV/c to be used.

The seven film analysis groups in universities and a group at the Rutherford High Energy Laboratory expect to devote a considerable effort on the setting up of beams for the bubble chamber at C.E.R.N. In addition to the great intrinsic interest in this work, it will provide invaluable experience before "Nimrod" beams are commissioned at the Rutherford High Energy Laboratory.

The National Film Analysis Equipment Programme

In addition to the British national hydrogen bubble chamber, several universities have small hydrogen bubble chambers of their own which have been in operation for some time, while other chambers, for example the N.I.R.N.S. propane chamber, are under construction and will also provide a substantial amount of film for analysis. It is expected that in all an annual minimum of one million photographs of bubble tracks generated by nuclear particles will ultimately be available to U.K. groups, and in order to provide automatic methods of analysis the seven universities concerned in bubble chamber work (Birmingham, Cambridge, Glasgow, Liverpool, Oxford, and Imperial College and University College, London) decided at an early date to co-operate in a programme for the development of the necessary analysis equipment.

This programme, also supported by a grant from D.S.I.R., has been undertaken in parallel with the construction of the British national hydrogen bubble chamber and has been the responsibility of the same Management Committee. It provides for 22 scanning machines, 7 automatic measuring machines and 3 manual measuring machines, which will be allocated among the groups concerned. The scanning machines will be used to identify events which will ultimately be measured, and the aim will be a high-speed programme capable of cataloguing pictures at a rate comparable with their production by the bubble chambers; the measuring machines will enable the co-ordinates of the bubble images to be measured and recorded. The automatic machines (Plate 7) will allow automatic track-following using servo-controlled mechanisms, and an event of average complexity will be analysed in about ten minutes. In the manual machines the track-following will be carried out by the operator and the analysis will therefore be much slower; however, this method will be particularly useful for the individual study of special events. The data from the machines will be recorded on paper tape for processing by computer.

The optical design and the supervision of the mechanical and electronic work have been undertaken by a group at Imperial College. These designs have been discussed stage by stage with the seven university groups and the instruments are now being manufactured under contract.

The integrated programmes for the construction of the British National Hydrogen Bubble Chamber and the National Film Analysis Equipment provide an excellent example of university collaboration in nuclear physics. In all D.S.I.R. support has amounted to £820 000.

New Machines

Two new large machines, provided through special research grants, are nearing completion. The 12MeV tandem Van de Graaff at Liverpool University will shortly start operation, and the heavy ion linear accelerator at Manchester University is scheduled for completion in 1962. The provision of these two facilities has been supported by grants totalling £766 000. More recently the Department has announced a grant of just over £¾ million towards a new nuclear physics centre at Oxford University under Professor D. H. Wilkinson. This will provide a particle accelerator of novel design for an extended programme of long term research on nuclear structure. The grant is the largest single award ever made by D.S.I.R. and the total Government support for the project is approximately £1 million, inclusive of the cost of certain work being carried out by N.I.R.N.S. and assistance from the U.G.C.

OTHER BRANCHES OF PHYSICS

Number and Value of Grants Awarded

1956/57 (Oct–Sept)		1957/58 (Oct–Sept)		1958/59 (Oct–Sept)		1959/60 (Oct–Sept)	
No.	Value	No.	Value	No.	Value	No.	Value
12	£36 345	6	£31 470	16	£72 955	17	£147 731

Nuclear physics and the studies that may be grouped together as low-temperature and solid-state physics are now the largest fields of physics research and each is served by a separate sub-committee of the Research Grants Committee. However interest in other fields is by no means small, and the Physics Sub-Committee, which covers these fields, has recommended already a wide range of awards, mainly for investigations of the gaseous state and covering particularly meteorology, physics of the upper atmosphere, plasma physics, optics, and molecular physics and spectroscopy.

Cloud Physics

A group at Imperial College London under Dr. B. J. Mason has received D.S.I.R. support for work on the basic microphysics processes involved in the formation of clouds and rain; these include the condensation of water vapour, the supercooling, nucleation and crystallization of liquid water, the growth of ice crystals from the vapour, and the growth mechanisms of snow flakes, raindrops and hailstones. These researches have pointed to the need for a thorough study of the structure and physical and chemical properties of water in its various forms and, to this end, an inter-departmental research programme has now been set up in Imperial College.

Much attention has been devoted to the supercooling and freezing of water. Two distinctly different relationships have been established; one characterizes heterogeneous nucleation by foreign particles, and the other, for very pure water, homogeneous nucleation without the aid of foreign particles. Freezing of the drops is often accompanied by cracking and even violent disruption of the ice shell, and the ejection of small splinters of ice. This suggests a mechanism by which ice-crystal production in clouds may be rapidly increased and, since the splinters are electrically charged, they are also of interest in connection with charge generation in thunderstorms.

The ice-nucleating ability of various types of soil particles and mineral dusts has been tested. Twenty-one substances, mainly silicate minerals of the clay and mica groups, are found to produce ice crystals in supercooled clouds at temperatures of –18°C or above, and of these ten are active above –12°C. The most abundant of these is kaolinite, active at –9°C, and this may well be the major source of atmospheric nuclei.

The critical temperatures and supersaturations required for the epitaxial growth of ice crystals on a number of single-crystalline substrates have been determined. Many pictures have been obtained to show that nucleation occurs preferentially at growth steps, cleavage steps, and other special sites on the substrate surface.

Considerable effort has been devoted to the growth of ice crystals from the vapour and the formation of artificial snow crystals (Plates 2 and 3). The crystals assume the following sequence of form or habit in the temperature range 0 to –30°C: hexagonal plates: needles: hollow prismatic columns: plates: dendritic crystals: plates: prismatic columns. When crystals growing at a particular temperature are suddenly transferred into a different environment, further growth follows the habit characteristic of the new conditions, producing crystals of composite habit. Some striking changes in habit and growth rate have been produced by the application of electric fields.

It has been found that the sign and magnitude of the electrical charging which results from collisions between ice crystals and a simulated hailstone is governed by their difference in temperature, the hailstone becoming negatively charged if it is warmer than the rebounding crystals. The magnitude of the charging is proportional to the temperature difference but rather insensitive to the size and impact velocity of the crystals. The freezing of supercooled droplets on an artificial pellet of soft hail is accompanied by the ejection of positively-charged ice splinters, the hail pellet acquiring a negative charge.

It is believed that this charge separation is the principal mechanism responsible for the electrification of thunderstorms and the origin of lightning, and that this depends essentially upon a thermoelectric property of ice, i.e. the preferential migration of protons under the influence of a transient temperature gradient.

Ionospheric Research: The distribution of electrons in the ionosphere

Ionospheric research in the universities has been concentrated in three groups which have worked closely together for many years; they are the group under Mr. J. A. Ratcliffe at Cambridge (until he joined D.S.I.R.), under Sir Edward Appleton at Edinburgh, and under Professor (formerly Dr.) W. J. G. Beynon at

Swansea and Aberystwyth. The groups have individually received D.S.I.R. support on a number of occasions, but a better picture is given by looking at the work as a whole, noting the inter-relationship of the work of the groups.

Routine vertical radio soundings of the ionosphere are regularly carried out at some 160 observatories. These vertical soundings provide a photographic record or "ionogram" in which the "equivalent height" of reflection of radio waves is plotted against the frequency of the wave. The solution of many theoretical and practical problems concerning the ionosphere requires a knowledge of the electron concentration in the ionosphere as a function of the true height and it has long been appreciated that this electron density/height profile could, in principle, be obtained from the experimental ionograms. However, this involved laborious computation, and methods of calculation suitable for use with a digital computer have been developed under a grant from D.S.I.R. by a group of workers under Mr. J. A. Ratcliffe at the Cavendish Laboratory, Cambridge, before he became the Director of the Radio Research Station of D.S.I.R. in October 1960. Tables of electron distributions for each hour of the day, for different seasons, for different solar epochs and for different places have been published, and as a direct consequence of this work several other laboratories are now producing similar tables on a routine basis: these provide the basic information required for a satisfactory theory of the ionosphere.

(i) *Studies of the F Layer.* Once it was known in some detail how the height-distribution of electrons changed from place to place and from time to time it was possible to consider the processes by which the electrons in the upper (F) region of the ionosphere were produced and lost.

In 1946 it was discovered by Sir Edward Appleton that the F2 layer of the ionosphere is distributed, over the world, according to magnetic latitude and not, as one might expect, according to geographical latitude. At the same time it had been found that equatorial conditions were anomalous, there being a belt of low ionization in the F2 layer, centred on the magnetic equator. Subsequent work on this layer by the group at Edinburgh University was directed towards elucidating further this identification of geomagnetic control and the equatorial anomaly. A world survey of F2 layer equivalent height variation during the seasons of the year gave independent evidence supporting the conclusion that "the ionospheric equator in the F2 layer is the geomagnetic equator", a result which has now received general acceptance. All the theoretical attempts to explain F2 behaviour are now based on some form of geomagnetic control.

Later the global picture of the variation of F2 layer ionization over the solar cycle was studied. For this purpose world maps were plotted of the ratio of the F2 layer critical frequency at sunspot maximum and sunspot minimum. According to simple theory, an attachment law being assumed for the rate of electron disappearance, this ratio should be constant at all places and all times. The Edinburgh results were, however, in disagreement with such a prediction. In high latitudes the ratio differs little from the value 2 over the day and night under equilibrium conditions; however, anomalous results were again found in equatorial regions which are characteristic of the anomalous belt centred on the magnetic equator. For example, it was found that values exceeding 4 are observable at magnetic latitudes 18°N and 18°S during the late evening hours and in more recent studies it became clear that this remarkable evening concentration of ionization is due to electronic diffusion, along the earth's lines of magnetic force, from a high level source at the magnetic equator. There is a kind of "fountain effect", ionization being first elevated at the equator, between 7 p.m. and 8 p.m. and then diffused, north and south, to appear some hours later at magnetic latitude 18°N and 18°S. This remarkable geophysical effect has important practical consequences; it is associated with marked electronic turbulence which is the cause of the well-known difficulties experienced in transmitting short waves across equatorial regions during local evening.

(ii) *Studies of the E Layer.* Some 75 years ago the English physicist Balfour Stewart suggested that the well-known regular daily variations in the earth's magnetic field were caused by large electric currents flowing in the terrestrial upper atmosphere. This was the origin of the so-called "dynamo theory" of terrestrial magnetic variations. However, studies have shown that the ionosphere is not only a dynamo, but a motor as well, and it has been found that such motor action produces measurable distortion of the ionosphere at the levels at which the currents flow. A careful study of E layer anomalies by a group at Edinburgh University and by a group at the University College of Wales, Aberystwyth, under Professor W. J. G. Beynon, has shown that these daily variations in the magnetic field can be correlated with perturbations in both the height and electron density of the E layer. An important conclusion of this work is that at least one ionospheric current system, of the kind originally postulated by Stewart, flows at the level of the E layer.

It has long been known that the normal E layer is produced by solar radiation and that certain characteristics of the layer are closely related to variations in solar activity. Careful studies of the sensitivity of the E layer to solar activity changes have been made by the Aberystwyth group and certain significant differences found between the short-period (27 days) and long-period (11 years) sensitivity of the layer. Attempts have been made to explain these facts in terms of the combined effects of variations in the background radiation and in that from active areas on the solar disc.

(iii) *Ionospheric Irregularities and Drifts.* When a radio wave is reflected from or transmitted through an irregular ionosphere is produces at the ground a pattern of intensity which is irregular and changing. Before 1956 methods had been developed, with the aid of D.S.I.R. grants, for observing this pattern and deducing the size, shape, and movements of the ionospheric irregularities. The movements consist of a random part superimposed on a regular "drift-like" motion. Particular attention has been paid to studies of these irregularities by the groups at the Cavendish Laboratory and the University College of Wales, Aberystwyth.

The group at Cambridge has studied certain aspects of ionospheric drifts and irregularities and has shown that the "diffraction pattern" method refers to drifts near the level of reflection. Results obtained by the diffraction method have been compared with, and shown to be generally consistent with, those obtained by other methods. It has also been shown that there is significant correlation between the cause of radio star scintillations and "spread F" echoes. A theoretical study has also been made of the reflection of radio waves by an irregular ionosphere.

The group at Aberystwyth, most of whom worked on the problem at Swansea, has studied the drift velocity in the lower part of the region (75–90 km) by means of observations on the fading of medium-frequency continuous waves reflected obliquely from the ionosphere. A study of these measurements and of others obtained at Cambridge and Manchester by quite different techniques showed that there is a minimum drift velocity at a level near 85–90 km which may be associated with the temperature minimum known to exist near this level. Drifts in the F region were also measured by the Swansea group by the observation of large scale ionospheric irregularities at three stations some 50 km apart. It has been found that the drift velocity and the prevailing degree of magnetic activity are related. This is especially the case for F region drifts where detailed correlation between drift velocity and magnetic activity has been observed. It has been found that within the F region there is generally a positive height gradient of velocity of the order of 1 m. sec^{-1} km^{-1}.

Plasma Physics

The scale and range of Government research on controlled thermonuclear reactions, and in particular the declassification of A.E.R.E. work in 1958, has stimulated an increasing interest in plasma physics in the universities. Grants from D.S.I.R. have allowed the purchase of equipment necessary for experimental work in this field.

Experiments on high temperature plasmas, starting with pioneering work on high current discharges, have been carried out in the Department of Electrical Engineering at Liverpool University for the past thirteen years. Recently a grant from D.S.I.R. to Professor J. D. Craggs has made possible the construction of a new condenser bank of some 50 kilojoules using the latest high-voltage low-inductance condensers. The main purpose of this project is to study the temperatures of plasmas and to achieve greater precision in measurements. The group also hopes to develop new methods of measuring discharge temperatures initially particularly in the region of 10^6°C and upwards. A momentum separator device is now being constructed for investigation of the energy distributions of the positive ions. The Department of Electrical Engineering at Sheffield University under Professor A .L. Cullen, also supported by a grant from D.S.I.R., is applying millimetre waves to the investigation of almost fully ionized gases. The condenser bank which has been installed has so far been used at energies up to 10 kilojoules; extension to the full energy of 30 kilojoules will take place shortly. Several new lines of research have been started: an assembly of Faraday cages has been built in order to analyse the current distribution and the types of heavy charged particle present in the discharge; an 8-mm microwave probe has been set up and measurements of transmission and reflection made; and the variation in the discharge configuration is being studied optically using photocell recording.

High Current Condenser Discharges through Gases

A research group, supported by a grant from D.S.I.R. was formed at Imperial College under Dr. R. Latham in 1955, to study the formation and stability of linear "pinched" discharges of heavy currents. Most of the work to date has been on discharges of currents of about 100 kA in argon at a pressure of 50–1000 μ and using only part of a large condenser bank storing 250 kilojoules (Plate 12). The formation of the discharge has been examined by fast photography and it has been found that a symmetrical axial core is present a few microseconds after the discharge starts. Evidence has been obtained on the duration in time and physical size of this axial filament.

At a somewhat later stage in the discharge cycle the column expands radially and collapses again to a second core and this process should repeat until radial equilibrium is reached. However, it is found that the radial oscillations cause strong instability, and by the time of the second collapse the discharge has become rather irregular in outline. The investigation of how the instability arises, what determines its rate of growth, and the size of the perturbations, has formed the main subject of research. It has been found that the radial acceleration of the plasma is an important factor.

It has also been found that conditions near the electrodes play a part in accelerating the break-up of the column. Many ad hoc experiments are being performed at the present time in an attempt to modify the electrode effects and to understand in more detail exactly how they arise. It may then be possible to use shorter tubes, which allow more energy per unit mass of gas for a given capacitor bank and might therefore be expected to give higher ion temperatures.

The behaviour of the ionized plasma has been observed by direct photography with magnetic probes inserted to measure internal magnetic fields, and with time resolved spectra scopes. It is hoped ultimately to be able to correlate these and use the results to give a complete detailed account of the linear pinched discharge.

TECHNOLOGY

Number and Value of Grants Awarded

1956/57 (Oct–Sept)		1957/58 (Oct–Sept)		1958/59 (Oct–Sept)		1959/60 (Oct–Sept)	
No.	Value	No.	Value	No.	Value	No.	Value
12	£39 670	26	£107 711	45	£171 491	57	£308 940

Although it was not intended by the Department that this should be the case, for many years D.S.I.R. grants were nearly all for research in pure sciences, but there has recently been a rapid growth in both the size and numbers of the grants for applied research and technology at universities, colleges of advanced technology and technical colleges. The fields of research covered by the Technology Sub-committee of the Research Grants Committee are very extensive, with the result that the support provided by grants is thinly spread. However, a great deal of support for research of this kind is already provided by industry, and D.S.I.R. hopes that the effect of its grants in technology will primarily be to help initiate work in promising new fields, which later will receive added support from industry as well as from university or college funds. Furthermore this could lead to improved collaboration in research between the laboratories of universities and colleges on the one hand and those of industry, including research associations, and Government on the other. It might also lead to the placing of development contracts with industry by D.S.I.R. D.S.I.R. therefore hopes requests will grow for its support for research in technology, and some of the lines along which it seems desirable that this should happen are discussed in paragraphs 8–15 of Section II of this chapter.

The following examples of current grants show something of the variety of projects which D.S.I.R. supports, and the first one illustrates the way in which D.S.I.R. can encourage a co-ordination of effort on a problem of special importance requiring a concentrated investigation.

Machine Tools

A series of research grants of particular importance has been made to four major centres for research into various aspects of machine tools. These centres, Birmingham University (Professor S. A. Tobias), Manchester College of Science and Technology (Professor F. Koenigsberger), The College of Aeronautics, Cranfield (Professor J. Loxham) and the Royal Technical College, Salford (Mr. A. W. Chisholm), have been awarded grants worth over £100 000 and the staff employed with the equipment provided have made substantial progress in this vitally important field of research. The progress of the work and the co-ordination of these programmes with those of the National Engineering Laboratory and the Production Engineering Research Association are reviewed twice a year by a co-ordinating committee under the chairmanship (during the period under review) of Sir Harold Roxbee Cox, now chairman of the D.S.I.R. Research Council. Close connection will also be maintained with the recently established Machine Tool Industries Research Association. The main emphasis of the four programmes is on problems arising from the processes of machining and grinding, but the allied problems of metal forming have not been neglected and research grants have been made to Imperial College, London, and Sheffield University, to construct or purchase presses for such work.

Image Intensification

In the application of electronics to optics, the problems of image detection and intensification are of fundamental importance in extending observations in such fields as astronomy, nuclear physics, spectroscopy and radiology.

D.S.I.R. grants have been used to support, at Imperial College, London, and under the direction of Professor McGee, six research projects to investigate this general problem. The basic principle of the work is to convert the optical image to an electron image by photoelectronic emission and then to intensify or multiply the electron image by various means and finally to record it on a photographic plate. In this way advantage is taken of the high efficiency of conversion of photons to photoelectrons. The individual projects are:

(i) *Thin Window Image Intensifier*. In an image tube the optical image is formed on a photocathode from which photoelectrons are liberated in numbers proportional to the light. These are accelerated and focussed to form an image on a fluorescent screen. Because of the high energy of the electrons, about 100 times as much light is liberated from the phosphor as falls on the photocathode. To avoid serious loss of light in an optical system for recording this image, the fluorescent screen is formed on the inner surface of a very thin, transparent mica window and a contact exposure is made with a film. This results in an overall gain in light of 50 to 100 times. By special design the tubes operate at sufficiently high voltage to give a good light gain without serious background light.

(ii) *Lenard Window Tube*. The Lenard Window Tube is a development of the intensifier described above in which it has been possible to make the mica window so thin and the voltage so high that the electrons penetrate right through the mica window and are recorded on a film pressed against the outside surface of the mica.

(iii) *Electron Image Multipliers*. Two methods are used to multiply the electrons in the electron image and increase their energy. In the first, primary photoelectrons are shot into a very thin film from which they knock out secondary electrons on the opposite side, which are accelerated and focused onto the next multiplying screen. Each primary electron produces about five secondaries and if this process is repeated five times it will result in the emission of about 3000 electrons for each single incidental primary electron. These electrons are accelerated to a small spot on a fluorescent screen to produce a bright spot of light. This results in a light amplification of about 10^5 and enables single photoelectrons to be recorded photographically or "seen" as individual scintillations. This tube has already given interesting results in nuclear physics and astronomy.

(iv) *Image Multiplier with Phosphor Photocathode Cascade*. This tube operates on much the same principle as the one just described except that the electron multiplication is achieved by projecting the primary electrons onto a thin phosphor screen laid down upon one surface of a thin transparent sheet of glass. On the opposite surface is a thin transparent photocathode from which the light from the phosphor releases a new batch of electrons. These are accelerated and focused onto another similar screen, passing through several stages and finally onto a phosphor screen. This, like (iii) enables single photoelectrons to be recorded, and it has some features which may be of special value. Very successful results with this tube have been achieved in the U.S.S.R. and U.S.A., but a good deal still remains to be done on the Imperial College project.

(v) *Charge-Integrating, Signal-Generating Tube*. In this project the aim has been to develop a television signal-generating tube, similar to a television camera tube, in which the exposure can be very long so as to build up on a storage target a charge image that is sufficiently large to enable just one frame of a television picture to be scanned. This method, besides being capable of great sensitivity, enables the record of the image to be in the form of an electrical signal which can be recorded (on tape, for example) or transmitted over distances. It may for example, be of great importance in astronomical space research.

(vi) *High-Speed Electron-Gating Tube*. In such electron image tubes it is possible to turn the image "on" or "off" at very short time intervals. A very successful design has been developed in which the electron "gate" can be completely opened or closed with a voltage pulse of about 5 V. This enables very high-speed operation of the order of 10-100 millimicroseconds to be achieved without undue distortion of the image.

Combustion Theory

An entirely different type of research supported by D.S.I.R. at Imperial College is the work on combustion theory under the direction of Professor D. B. Spalding.

The solution of second order non-linear differential equations is needed in combustion theory and one such equation is in terms of the temperature, distance and known functions of distance and temperature. The required solution is the temperature distribution along the distance axis and possibly a critical value of a parameter corresponding to the extinction point of a flame. Because of the difficulty of solving this type of equation analytically a resistance network analogue computer has been developed at Imperial College with the support of D.S.I.R.

This analogue device is similar in principle to the electrolytic tank, which has a continuous electrolyte covering the area in which the equation has to be solved. In the network analogue the area is divided into a mesh, the mesh points being joined together by a network of resistances instead of an electrolyte.

The electrolytic tank can solve only Laplace's equation but the network analogue can solve Poisson's equation also (in finite difference form) if the appropriate electric currents are injected into the mesh points. The adjustment of these currents is an iterative process and could be done manually but this is hardly practical with a fairly large number of network points. In this analogue device the process is automatic and a solution is obtained in a few minutes.

Fuel Technology

Sheffield, like many other towns and cities, has had a smoke pollution problem for many years. This is due to the special type of work done in iron and steel working, such as the reheating of billets and bars, and the annealing of semi-finished articles, where it had been thought for many years that a long smoky flame was necessary to avoid excessive scaling and decarburization of steel. Work done since 1949 sponsored initially by the D.S.I.R. Fuel Research Station (and now by the Warren Spring Laboratory) and by the Sheffield and District Clean Air Committee had solved some of the problems involved, and work had been done on the effects of furnace atmosphere on scaling and decarburization of various steels. The combustion of the volatiles from coal had been studied both in a small-scale apparatus and in a larger furnace. The combustion of a soot produced by the partial combustion of acetylene had been studied under conditions simulating the tail end of a smoky flame. In aerodynamic work on the mixing of a jet fired into a transverse stream, a cold model had been used to test a new mathematical theory for the path of the jet.

Since 1958 Professor M. W. Thring has received support from the D.S.I.R. research grants scheme for certain aspects of this work, particularly those related to the formation and combustion of coal smoke. The grant provides for the salary of a Research Fellow who is now in charge of all air pollution work in the Department of Fuel Technology at Sheffield University. In addition he supervises the research of Ph.D. students working on air pollution for the National Coal Board, the British Ceramic Research Association, and the Sheffield and District Clean Air Committee, thus ensuring effective co-ordination of the research.

Research on the ignition of domestic coke has resulted in the development of an igniter suitable for a domestic grate. The device, which has now been placed on the market, uses a small electric fan to produce a very hot flame from the combustion of paraffin, and is very effective for kindling coke. Work is also being done on the further development of a stove able to burn small bituminous coal with much less smoke than any other available domestic stove. It is hoped to make this appliance completely smokeless by the use of forced air. Work is also proceeding on the miniature forced-draught mechanical stoker for completely smokeless combustion of small high-volatile coal in a domestic water heater.

Civil Engineering

(i) *Steel Structures.* An investigation into the behaviour and design of steel structures subjected to pulsating and repeated loads, of vital interest to the civil engineering industry, required equipment capable of applying constant loads up to 25 tons at frequencies of 1 to 500 cycles per minute and of applying constant deflexions. No suitable commercial equipment was available. With the help of a research grant to Professor Sir John F. Baker, three machines have been designed and built in the Engineering Laboratories, Cambridge University. These machines are a constant-load hydraulic pulsator, a constant-deflexion hydraulic pulsator, and a constant-load or constant-deflexion mechanical-fatigue rig for small specimens. In addition, a set of six Amsler jacks for maximum loads between 1 and 25 tons has been purchased, together with an Amsler dynamometer for accurate load measurement and calibration.

(ii) *Arch Dams.* Present developments of power and water supplies abroad provide considerable opportunities for British civil engineers in the design and construction of arch dams. A number of university investigators decided in 1959 to undertake investigations into the stresses in arch dams (Plate 14) and their effect on design methods, and financial support was obtained from a group of civil engineering consultants and from D.S.I.R. The work of the investigators, Professor S. C. Redshaw (Birmingham University), Professor D. N. de Garrs Allen (Sheffield University), Professor P. B. Morice and Dr. J. R. Rydzewski (Southampton University), Professor S. R. Sparkes and Miss L. Chitty (Imperial College, London) and Mr. C. Snell (University College, London) is co-ordinated by a special committee of the Institution of Civil Engineers.

Transistors and Semiconductors

An example of the way in which D.S.I.R. has helped the establishment of a new research group in a university is to be found in the Department of Electronic Engineering at Bangor, where a team is actively engaged on various researches on semiconductors and transistors. In 1958 work was started on a series of investigations aimed at providing an increased understanding of the small-signal and noise properties of alloy-type transistors. By means of careful measurements over a wide frequency-range a consistent equivalent circuit has been established for the base resistance and collector capacitance. Measurement of high-frequency noise in commercial transistors has revealed excess noise in many cases. It has been established that the excess noise arises at the surface around the collector and is associated with imperfect geometry. A study is also being made of some of the factors affecting lifetimes of minority carriers in the base of a transistor.

A second group has been investigating the use of transistors in circuits for generating very short pulses of electric current. In the course of this work a wide-band transistor amplifier for low frequencies of up to 100 Mc/s with a gain of 20dB has been produced. A transistorised sampling-oscilloscope with a band-width of 450 Mc/s has also been developed. New systems are being investigated for pulse-shaping and pulse-viewing using variable-capacitance diodes in distributed circuits.

Another series of investigations is being made into the use of variable-capacitance diodes in parametric amplification. One of the main objects in the first stage is to establish the important parameters which determine the effectiveness of diodes operating in this manner. Amplifiers of various types and covering a wide frequency range are being studied. Measurements are being made over the frequency range 100 kc/s to 10 000 Mc/s to establish the diode equivalent circuit. At the same time the use of variable-reactance diodes as harmonic generators is being investigated in order to determine, among other things, their possibilities for the generation of millimetre waves.

Although these research groups have been in operation for a fairly short time, some useful results have already been achieved, and it would seem that an effective research school is being established.

Chapter 4

Human Sciences

EARLIER INTEREST

1. D.S.I.R. first became interested in the human sciences* in 1918 when, in conjunction with the Medical Research Committee (now Council), it appointed the Industrial Fatigue Research Board. Responsibility for the Board, originally with D.S.I.R., passed to the Medical Research Committee, and the D.S.I.R. contribution stood at £1000 p.a. for the first two years. A final grant-in-aid of £8000 for 1920–21 ended the Department's formal association with the Board. In the financial crisis of 1921 the future of the Board was in the balance, and D.S.I.R., although no longer responsible, showed keen interest in its survival. The Board continued and, under the title of the Industrial Health Research Board, sponsored research up to 1947.

2. More recently D.S.I.R. became active in fields of study within the human sciences; joint responsibility for work concerned with human factors (human relations and individual efficiency) in industry was given to D.S.I.R. and to the Medical Research Council (M.R.C.) in 1950 by the Lord President of the Council, Lord Morrison, then Mr. Herbert Morrison. He acted on the recommendation of the Committee on Industrial Productivity that the promotion of research started in 1947 by the Committee's Panel on Human Factors (the Schuster Panel) should be put on a permanent basis and two joint D.S.I.R./M.R.C. Committees were set up, on Human Relations, and on Individual Efficiency. It so happened that U.S. Conditional Aid Funds became available just when these Joint Committees were launched, and expenditure from this source, totalling £175 000 during 1953–1957, reached a peak of £76 000 in the year 1955–56. D.S.I.R. funds were also involved but it was not until 1956 that they were committed to any considerable extent.

THE JOINT COMMITTEES

3. The Joint Committees ended their work in 1957 and the final reports in which they appraised their work and made recommendations for the future were issued in 1958. The two Joint Committees were able to look back with some satisfaction on their achievements and forward with some confidence. To quote from the final report of the Committee on Human Relations in Industry: "During our period of office we have seen a real development of research in the field of human relations in industry and, what is equally important, a big growth of industrial interest in such research. The position today is very different from that which existed in 1953 when we were appointed. The opportunities and needs are now more clearly understood, and they have changed—partly, we hope and believe, because of our own efforts. We understand that as a result of these developments the intention is to reorganize the machinery for advice on Government support. We are glad to know that both the Department of Scientific and Industrial Research and the Medical Research Council intend to continue to support research in our field and to foster industrial interest".

---

* For the sense in which the term "human sciences" is used here, the reader is referred to the glossary. Broadly speaking it is confined to those aspects of psychology, sociology and anthropology which are relevant to the needs of industry.

4. The following passage is taken from the report of the Committee on Industrial Efficiency in Industry: "The need we see for the future is to encourage the parallel growth of fundamental and applied research as well as of the application of results. There is already in this country a sound nucleus of fundamental research activity, within our own research programme and elsewhere, and with the rapidly growing evidence of industrial interest in the application of its results we look forward with confidence to a healthy and balanced growth of activity".

FORMATION OF THE D.S.I.R. HUMAN SCIENCES COMMITTEE

5. Experience with the Joint Committees had clarified the division of responsibility between the Councils, and each Council made its own arrangements. D.S.I.R. appointed a Human Sciences Committee (H.S.C.) of its Research Council in 1957. Its present terms of reference, shown at Appendix A, give it two principal functions: the general function of keeping under review the development of the human sciences in relation to industrial needs, and the specific function of recommending the award of D.S.I.R. research grants in this field.

INITIAL REVIEW OF RESEARCH NEEDS

6. Faced with the responsibility for encouraging research in psychology and sociology applied to industry, the Committee began to survey the scene as it appeared on the disbanding of the Joint Committees. The experience of these former Committees had shown that industrial problems have human and technological aspects that are intimately interwoven, and that whether research took as its objective the improvement of industrial efficiency, the well-being of people in industry, or broader goals unconfined by the factory walls, it would have to be conducted in a setting in which the technology, which influenced the nature of the industrial organization and the people manning and operating the technology were all of significance. Moreover the distinction between "basic" and "applied" research was also hard to draw. As with other applied sciences, successful research in the human sciences combines the selection of practical problems with the study of underlying theoretical issues.

7. Given time the human sciences would almost certainly develop, even without government intervention. Observing the practical applications in the U.S.A. and elsewhere, industry would demand a supply of research workers to tackle the problems; but what would be much less certain was whether this would happen soon enough and whether the effort thus developed would be distributed to the best advantage. The problem of British industry and the social setting in which the problems occur are not sufficiently similar to those of the U.S.A. for the results achieved there to be applied in the U.K. with guarantee of success. For the U.K. then, this was not a field of activity in which patience and academic interest allied to industrial interest would provide all the development required: rather it was an underdeveloped area in which a good deal of judicious preliminary aid was needed to ensure a satisfactory development.

FOSTERING OF RESEARCH GROUPS

8. The first requirement was that the flow of research funds should be steady and aim to keep in step with the problems requiring solution, the expansion of facilities and the availability of people of good quality trained in the growing

disciplines. Partly because of the breadth and ramification of some of the problems in the human sciences, and partly because of the quantity of the data that must sometimes be obtained, successful work in this field is often team work. But stable research teams were lacking and sometimes good research assistants could not be offered security of tenure. Too often a good piece of research was not followed up as it should have been because the team that provided it had scattered. These disadvantages flowed from the former *ad hoc* character of the financing of research in this field.

9. Much successful preliminary aid was given during 1953–57 through research contracts placed by the Joint Committees and financed initially from the U.S. Conditional Aid Funds. As a result by late 1957 when the Research Council set up its Human Sciences Committee with powers to award D.S.I.R. research grants, there existed a number of sound research groups led by experienced investigators. High on its list of priorities the new Committee placed the encouragement of these research groups by helping them to develop continuing research programmes. Research schools with reasonable prospects of continuity can be relied upon not only to develop coherent programmes of research but also to serve as training grounds for research workers. The success of those research projects in the human sciences which are carried out in an industrial setting, depends to a large extent on the acceptability to industry of the research worker as well as his research, and consequently the young research worker needs to be trained in a group experienced in handling the delicate relationship with the human scientist's laboratory.

10. Accordingly at the outset the Committee planned to devote a fairly large proportion of its limited money to supporting five or six proved centres, provided they continued to put forward projects of a high standard, and to use the balance to support worthwhile investigations among the wider field of applicants. Events overtook this policy: the number of very good applications from elsewhere was larger than anticipated. Moreover the expansion of existing research groups was inhibited by the lack of resources of the kind not provided by D.S.I.R. Research Grants. Important among these was accommodation, for many groups were 'making do' in premises inadequate even for their existing needs. Thus a greater proportion of the Committee's grants than was originally intended has been used to support projects at emergent centres of research.

FURTHER REVIEW OF RESEARCH AND TRAINING

11. Partly as a background to its grant awarding activities, and partly to enable it to judge whether D.S.I.R. should inaugurate a research programme of its own, the Committee decided to survey the human sciences within its purview, in order to try to identify the points of growth and the gaps that needed filling. To this end a series of conferences was held. At the first of these, representatives from industry, academic and other research groups discussed research and training needs in the field of ergonomics. At the second, psychologists and sociologists from universities discussed with the Committee the areas of research which would be most valuable to industry. At the third, teachers of management subjects from industry, the universities and technical colleges discussed the background of research to management studies. Research on training and management and "innovation" were the subjects of two further one-day conferences bringing together research workers and people from industry.

12. From these conferences and other studies undertaken by the Committee, certain focal points of potential growth were identified. Among these four have been especially noted—industrial recruitment; control skills; the impact of change; and the analysis of, and training in, conventional skills. These focal points have served not only to help in assessing the priorities of grant applications but also as a background against which D.S.I.R.'s own future programme of research in the human sciences (then the responsibility of Headquarters Office but now of Warren Spring Laboratory) could be formulated. To this end a meeting of human scientists in Government departments was organized to obtain a general picture of their work and ideas about areas of research which might be supplemented by a D.S.I.R. programme.

SOME PROBLEMS ASSOCIATED WITH GRANTS

13. In fitting into the pattern already established for D.S.I.R. Research Grants and Training Awards in other sciences, certain difficulties are encountered which are inherent in the present state of the human sciences. For example the human sciences are less well provided with senior teaching posts at universities, and the published regulations for D.S.I.R. refer to grants for "investigators of acknowledged standing"; readerships are scarce in the human sciences, and some universities still have no separate departments and professorships for some of the human sciences. The scarcity of teaching posts, combined with the insecurity in research which involves changing jobs every two or three years has made a career in this field unattractive, and experienced research assistants are often hard to find. As a result the ideal team an investigator may have in mind when formulating his proposals may have to be modified or the project delayed while the search for suitable staff continues. Postdoctoral research assistants are therefore relatively few, and rather more research assistants provided through D.S.I.R. grants wish to register for higher degrees in this than in other branches of science. Normally D.S.I.R. is able to agree only to rates of pay roughly equivalent to those of its research students, but the more mature research assistant suitable for industrial projects will often demand a higher rate. However while accepting that the human sciences have special problems and a requirement for more flexibility, the aim has been wherever reasonable to adhere to the well-tried practices followed by D.S.I.R. when making grants and awards in other scientific fields.

COMPOSITION OF THE HUMAN SCIENCES COMMITTEE

14. There is good balance between academic and industrial interests in the present membership of the Human Sciences Committee of the Council. On the academic side four of the five members are professors of psychology or sociology; industry is represented by two trade union officials, one member comes from senior industrial management, and another from labour management. Two further members are managers of large industrial research organizations. One of the trade union members, who is also a member of the Research Council, is chairman of the Committee. The fifth academic member is a professor of political economy and a member of the Research Council, and as chairman of the Council's Economics Committee he ensures that there is a liaison with that body. As the Committee's activities touch on the interests of other Government departments, in particular the Ministry of Labour, the M.R.C., the Ministry of Education and the University Grants Committee (U.G.C.) these departments are invited to appoint Assessors to the Committee. This membership (which is

set out in Appendix B 2 (iv), page 157), ensures that the Research Council receives well-balanced advice, and that every proposal for a grant is examined to assess not only its scientific merit but also its interest to industry and its potential relevance to industry's needs.

15. The M.R.C. also awards grants in the human sciences. In most cases there is little difficulty in deciding whether a proposal comes within the scope of D.S.I.R. or the M.R.C., but there are some on the borderline which are harder to decide. Broadly speaking, psychological studies of a clinical nature, comparative experimental psychology and studies which have a strong physiological orientation are in the field of the M.R.C. There are some studies, such as fatigue studies, which, although of considerable industrial relevance, have for many years been of interest to the M.R.C. Other experimental investigations of skilled performance may lie close to the work undertaken by the M.R.C. Applied Psychology Unit at Cambridge, its Industrial Psychology Unit at University College London, or other M.R.C. Units. In such cases co-operation is necessary with the M.R.C. in order to determine which body shall handle an application for a research grant, and this is assisted by their appointment of an assessor to the H.S.C.

16. The human sciences in their relation to the needs of industry touch the interests of the Ministry of Labour at several points. When considering such projects as studies of the industrial population or of industrial relations D.S.I.R. looks for advice to the assessor on the H.S.C. representing the Ministry of Labour.

17. Most grants are made to universities, but some are made to colleges of advanced technology and like institutions. It is therefore valuable for the Committee to have available the advice not only of an assessor from the U.G.C. but also one from the Ministry of Education.

18. These assessors assist the Committee not only in its consideration of applications for research grants, but also in the consideration of other matters of D.S.I.R. policy in the human sciences where their parent bodies may have an interest.

SUB-COMMITTEES

19. The Committee has found the need to appoint several sub-committees to deal in more detail with some of its responsibilities. One of these undertakes preliminary scrutiny of applications for grants, and others look after activities of special interest. In the period under review four sub-committees were appointed, namely the Grants Sub-committee, the Ergonomics Sub-committee, the European Productivity Agency Sub-committee and the Work Study Sub-committee (now disbanded). Membership and terms of reference are listed in Appendixes B 2 (iv) and B 1 (v) respectively.

(i) *Grants*

20. As the number of applications for research grants increased, the main Committee had to devote more and more time to their detailed scrutiny, till, in November, 1959, a small Grants Sub-committee was set up to consider applications and make recommendations to the main Committee. At the end of the period under review four academic psychologist and sociologist members of the parent Committee sat on the Sub-committee under the chairmanship of

an industrial member. This arrangement has proved extremely successful because it enables fuller professional scrutiny to be made of the applications, and leaves more time at the main Committee meetings for discussion of broader policy matters. In addition the period between the meetings of the Sub-committee and the main Committee provides an opportunity to obtain from the investigator and referees any further information required as a result of the Sub-committee's discussion.

(ii) *Ergonomics*

21. In January 1958 D.S.I.R. called a special meeting to consider ergonomics with particular reference to training in that new and rather hybrid discipline. The sense of this meeting was that, although the field of ergonomics was of growing importance to industry, the results already achieved were not widely enough known, and the facilities for producing people trained in ergonomics were inadequate. Action by D.S.I.R. to stimulate both the dissemination of research results and training in ergonomics was recommended to the H.S.C., which then appointed an Ergonomics Sub-committee to assist it in these activities. This Sub-committee's terms of reference (given at Appendix B 1 (vi)) broadly authorize it to advise the H.S.C. on developments in ergonomics, to survey existing research, and to advise on the most effective methods of disseminating in industry the results of ergonomics research. This dissemination is now undertaken by the Information Division of D.S.I.R., and a 3-day conference on Ergonomics in Industry held in September 1960 was attended by over 300 representatives of senior industrial management. A working party of the Sub-committee has been studying the need for consulting services in ergonomics and the necessary steps that would have to be taken to assist their development.

(iii) *European Productivity Agency*

22. At the end of 1957, the H.S.C. was invited to become the "National Committee" in the human sciences field in the U.K., recognized as such by the European Productivity Agency (E.P.A.) of the Organization for European Economic Co-operation (O.E.E.C.),* and accepted this responsibility. In July 1958 the Committee appointed an E.P.A. Sub-committee with terms of reference "To consider such E.P.A. matters as fall within the responsibility of the Human Sciences Committee and to report from time to time".

RESEARCH PROGRAMME

23. In addition to recommending the award of research grants to suitable outside investigators, the Committee was responsible during its first year for the Department's own research programme in the human sciences. This included seven projects started under research contracts placed by the former Joint D.S.I.R./M.R.C. Committee on Human Relations, and a further contract placed by the new H.S.C. with Manchester University, for a study at Leigh. This latter study was to provide data to compare with those from the study of school leavers' transition to work, which was being carried out under a grant awarded to Sheffield University. Another aspect of the D.S.I.R. programme was a research project in industrial sociology initiated by the same Joint Committee with Conditional Aid Funds, and conducted by a small group of D.S.I.R. Headquarters staff. This activity was among those taken over by the H.S.C.

---

* Now O.E.C.D.—Organization for Economic Co-operation and Development.

on its formation in 1957. The project was an investigation into the effects on an industrial firm of the introduction of work study. For several years there was in existence a panel of outside specialists for advising D.S.I.R. on this research, but this panel was reconstituted as the Work Study Sub-committee of the H.S.C. It continued to guide the project until 1959 (when the work became part of the programme of the Warren Spring Laboratory), and it advised the H.S.C. as required in the field of work study. The first report has been issued and the second is in preparation, but with the transfer of the work to the Warren Spring Laboratory the panel ceased to be a sub-committee of the H.S.C.

24. As part of a reorganization in 1959, a Human Sciences Research Section was set up at the Warren Spring Laboratory at Stevenage, and to it passed the responsibility for D.S.I.R.'s own research programme in the human sciences. Although the grant-awarding responsibility was retained at Headquarters, this transfer of research responsibilities from D.S.I.R. Headquarters to a research station brought the human sciences into line with other branches of D.S.I.R.'s scientific activities. With this change, and with the fostering of research training in the human sciences through Studentships and Fellowships, which was the responsibility of the Postgraduate Training Awards Committee with its Human Sciences Sub-committee, the "human sciences in relation to industrial needs" were by the autumn of 1959 fully integrated into the organization and structure of D.S.I.R. on the same lines as other branches of science and technology covered by the Research Grants Committee.

OTHER ACTIVITIES

25. Apart from serving the H.S.C. and its sub-committees and administering the grants awarded, the Human Sciences Section of D.S.I.R. Grants Division has been responsible for other activities related to its main duties. These include the maintenance of a register for the E.P.A. of research in the human sciences, dealing with inquiries related to research in its field, and the administration of grants awarded on the recommendation of the H.S.C.

A REGISTER OF RESEARCH

26. The E.P.A. maintains a register of research in the human sciences. The task of collecting and collating information concerning the United Kingdom was undertaken by the Human Sciences Section in 1958. A complete census was taken of the research being carried out in the human sciences applied to problems of work, and this was published by E.P.A. as its "Register of Research in the Human Sciences Applied to Problems of Work and Directory of Relevant Institutions—United Kingdom". Responsibility for further work in this connection has now been transferred to Warren Spring Laboratory, which plans to maintain an index of U.K. research with somewhat wider terms of reference. The first issue of this Register was published in March, 1962.

INQUIRIES

27. Because of the constructive way in which the Committee and its predecessors have encouraged research in the field of the human sciences, both industry and research workers now look to the Committee's secretariat in Grants Division for information about the branches of the human sciences within D.S.I.R.'s sphere of interest. It has been possible not only to put research and industry

into contact, with profit to both, but also to bring research workers into contact with others in the same field. This advisory service is now shared between Headquarters (Information and Grants Divisions) and Warren Spring Laboratory.

RESPONSE TO APPLICATIONS

28. The monies disbursed till 1957 by the Joint Committee were predominantly Conditional Aid funds, and the awards were technically contracts to carry out research that fitted into the broad programme chosen by the two former committees. The functions of the present H.S.C. are somewhat different, for while applications must fall within the Committee's general terms of reference the initiative comes from the university or other investigator who chooses the problem he wishes to study and submits his request for financial support to the Committee. If the proposed research is considered worth while, his university, college or other research organization is awarded a grant. The procedure and criteria are now similar to those for research grants in the other branches of science and technology covered by D.S.I.R. The new Committee's secretariat was therefore located in the newly formed Grants Division into which the administration of D.S.I.R. research grants for the human sciences was assimilated in the autumn of 1957.

29. The experience of the two Joint Committees had led the new Committee to expect a considerable flow of applications and its original estimates of likely expenditure were based on this expectation. By the end of the calendar year 1958, the Committee had considered 36 applications for grants and contracts and had recommended the award, in full or in part, of 24 of them at an estimated total cost of £59 000 over the next few years, allowing also for continuing payments under the seven research contracts referred to in paragraph 23.

30. During 1959 the Committee considered 17 applications for research grants, and recommended total or partial awards in the case of 14, at an estimated cost of £134 000. 1960 brought even more applications than did 1959. Twenty-two of these were considered by the end of July and it became clear that not only was the capacity for research in the human sciences growing in universities, colleges and elsewhere, but interest in the application of human sciences to industry was growing too.

31. From its inception the H.S.C. has set a high standard in its scrutiny, projects put forward by new and promising centres of research while still providing steady support for several established groups where the standard of the projects had been maintained. This policy has been carried out as far as money has permitted, and the grants awarded are listed in Appendix D 6, (ii). Although the majority of awards have been made to universities, awards have also been made to colleges of advanced technology and other colleges and to independent bodies undertaking research such as the Acton Society Trust, the Royal Institute of Public Administration, and the Tavistock Institute of Human Relations. The increased interest of the colleges of technology has been an encouraging feature, and in two cases research projects supported by D.S.I.R. have been continued by investigators who have moved from university departments to colleges of technology. The Committee agreed to transfer one small grant from Edinburgh University to Brunel College of Technology and, more recently, one of the largest from the University of Manchester to Birmingham College of Advanced Technology.

SUPPORTED PROJECTS

32. The fields of psychology and sociology in which the H.S.C. is mainly interested are listed below, but so far it has not been possible for the Committee to support a representative project in each of them.

(i) *Psychology*

- (a) *Industrial Skills:* problems of training, acquisition of skills, job evaluation, personnel selection, individual efficiency, work-assessment, incentives, effect of automation on industrial skills.
- (b) *Ergonomics:* "fitting the job to the worker", design and layout of work places, equipment; the function of the man in the engineering system.

(ii) *Sociology*

- (a) *Human Relations:* working groups, shift working, effect of mechanisation and automation on working groups; resistance to change.
- (b) *Industrial Organization:* organization of industrial firms, effects of technological change on organization needs; management of innovation; industrial conflict; managerial promotion policies; description of industrial populations, effects of industrial changes on social and community life.

33. It will be seen that all the objectives have a potential practical value for industry. Some of the problems concerning skills and ergonomics call for an increased knowledge of human capacities and of human function through laboratory investigations, some of which are carried out by industry itself, and all require close co-operation between industry and the research worker. For research projects, an *entrée* to suitable industrial organizations must be assured before a grant is awarded; and also where appropriate, the views of people in industry as well as in academic life are sought as to the importance and value of the topic. Although the projects supported by the Committee do not form a comprehensive programme in the sense that each is deliberately planned to fill a place in a scheme, the Committee's awards have usually been related to the centres of growth which were evident from the results of the research surveys referred to in paragraphs 11 and 12.

INDUSTRIAL RECRUITMENT

34. Among studies concerned with the industrial population and supported by D.S.I.R. are projects on the employment of married women and on the recruitment of technicians. Three grants and one contract have been concerned with aspects of the young worker and his passage from school to work. The importance of this subject is clear. Of the ingredients of the industrial process, i.e. money, materials and manpower, the last is the most flexible, the most valuable and the least susceptible to control. The Ministry of Labour collects excellent statistics of employment including juvenile employment, and maintains a youth employment service and a vocational guidance service. Vocational education is fostered by the Ministry of Education, by local education authorities and by sections of industry. However, much of importance remains to be learned about the way in which young people enter industry, how they get their first job, what is involved for them in the change from school to work, and how successful existing services are in guiding young people and placing them in a

job to which they are suited. The collecting of this information and the lessons which can be learned from it are valuable not only to industry but to the whole country. The Committee's interest in this field is now shared with Warren Spring Laboratory since that Station took over responsibility for the Department's own research programme, which included the research contract with Manchester University already mentioned.

CONTROL OF SKILLS

35. A second group of studies is concerned with industrial inspection and control of skills. Advances in mechanization and automation increase the importance of inspection, quality control and process control skills, in which the perceptual rather than the motor aspects are the most important; to the psychologist they are an important field of study. On the social side investigations supported by D.S.I.R. have established that an inspector's judgement tends to be influenced by factors other than the objective characteristics of the article or process he is inspecting. His standards are influenced by his own and other workers' expectations and his rôle brings him into conflict with other workers. We have here an area of utmost importance to industry and of great interest both to psychologists and sociologists.

IMPACT OF CHANGE

36. Increasing mechanization and automation, and other technical innovations, make their impact upon management in many ways. Not least is their significance for the structure and organization of industrial enterprises and for the kind of decision managers have to take. Major innovations may affect the status of whole groups of staff, as when office mechanization tends to blur many of the traditional distinctions between office and works staffs, both of whose jobs then merge fundamentally into the operation of machines. In fact, the forces that govern behaviour are seen at work most clearly when people are threatened by, or adapting themselves to change. Quite apart from its intrinsic importance to industry, this is a critical field of investigation for sociology and social psychology. Some of the successful projects now finished have been concerned with this topic of technological change, and three projects currently supported by D.S.I.R. have this as their focus.

INDUSTRIAL SKILLS AND TRAINING

37. Inspection and control skills have already been mentioned, and these have a special character; but within industry there is a vast range of more conventional skills in which the motor aspect is important. Skilled people are often scarce and training them is a long and costly process. Sometimes the skill is made needlessly complex by the design of the work process. More often the training is long and wastage is high because the skill required has not been adequately analysed and training inadequately synthesized. The analysis of skills and the examination and development of methods of training provide yet another focus for several investigations.

EVALUATION OF D.S.I.R. SUPPORT

38. So far the studies that fall into groups of investigations under a broad common head have been mentioned, but there are also others of considerable importance. In general the picture is encouraging and, despite its slow growth, the programme of research covers a wide field. Where D.S.I.R. is concerned

the Committee's aim throughout has been to foster and develop both the interest of research workers in undertaking studies in industry or of topics of concern to industry, and the interest of industry in the results of research. Consequently a great deal of university research in psychology and sociology now has an industrial orientation. It would however be unsatisfactory if this had been achieved at the expense of the advance of psychology and sociology as sciences. Accordingly the Committee has recently been discussing this wider question of a possible lack of balance in the public support of the human sciences imposed by its terms of reference. Nevertheless much of the research supported by D.S.I.R. in the human sciences has been of fundamental significance and has added to the body of scientific evidence and theory. Nowhere is this more true than in the field of the psychology of skill the study of which has led to new advances and theories in the central topic of perception.

39. In this chapter it has been possible to look back on a period of steady growth of work in human sciences applied to industry, for which D.S.I.R. and its Human Sciences Committee can take some credit. It is hoped that this growth can keep pace with the rapidly expanding needs of industry and potentialities of the universities and colleges.

40. The impact of the results of researches sponsored by the H.S.C. and its two predecessors the D.S.I.R./M.R.C. Joint Committees was the subject of a recent study by the Committee. Not only did many of the researches result in the firms concerned in the studies adopting changes to their benefit, but it became clear that a new awareness of, and approach to, problems of a human sciences nature had been aroused in many responsible managers. Where results were communicated by means of conferences, these in turn have had their effect in a wider sphere. The influence on industry of the researches so far reported is far from meagre and subsequent reports may be able to claim far more.

Chapter 5

Conclusion

1. This report has described the methods by which D.S.I.R. aids research and postgraduate training in science and technology in universities and colleges; it has given an account of the considerable growth in this aid during the period of rather more than four years, up to December 1960, following the D.S.I.R. Act of 1956 and of some of the problems which have arisen. In reviewing these activities it is appropriate to ask such questions as: Are these schemes serving their purpose? Does the expenditure represent a good investment of public money? Are these the best ways of helping research and training? What are the likely future developments?

2. There seems little doubt that the selective support by D.S.I.R. research grants of timely and promising researches, particularly in their initial stages, has had a significant effect on the research effort of the country. The substantially greater level of such support now being given has opened up new possibilities of which many lively research schools have been quick to take advantage. Furthermore, this support is making considerable difference to the smaller schools in establishing viable research groups with great benefit to the scientific life of their universities. It is equally certain that the provision, on a simple and equitable basis, of the means of training large and increasing numbers of postgraduate students is now a feature on which both academic staff and students are placing great reliance. In short, the evidence available to D.S.I.R. would seem to confirm that these schemes are serving their purpose.

3. The steady expansion of its financial support implies that D.S.I.R. is convinced that the benefits amply justify the large sums now being spent. However, this belief must rest partly upon a subjective assessment of the value of science and education, and upon a faith in the long-term value of basic scientific and technological research.

4. Mention should be made of a consideration which the Department has constantly in mind—the importance of administering public funds in support of university research and training without interfering with academic freedom. Research, more especially basic research, is often a gamble. The working out of imaginative ideas, sometimes on the basis of slight clues, or perhaps just intuition, may lead to whole new fields of knowledge, or to nothing. On the other hand, it is contrary to custom and tradition to encourage speculation with public money, in view of the very proper requirement of answerability to Parliament, and yet it is at the early uncertain stages of research that help is most necessary and most valuable. The faith which has been shown in the Department's work by Parliament, and the sense of responsibility shown by the Department's scientific advisers, have overcome this basic difficulty. Support for university and college research, with special grants from the Research Councils supplementing the general financial aid from the Government, is a combination which aims at providing ready and effective support while minimising interference with the institutions' freedom of action. Mutual understanding based on personal contact are required for this compromise to work satisfactorily.

5. It is the intention of D.S.I.R. that support for research and training in universities and colleges should keep in step with their growth and with their increasing interest in science. Nevertheless it is to be hoped that other sources, already providing substantial help of the same kind, will also grow. Benefactions, foundations and trusts, and notably some far-sighted and generous industries, provide a great deal of backing for scientific and technological research. These alternative sources of support are welcome, especially those provided by industrial firms that see the importance of basic research for their future prosperity. They give the university scientist healthy independence of Government support and provide most valuable links between the academic and industrial scientists.

6. But in the end the Government must still be prepared to receive an increasing flow of demands for support and to carry an increasing financial responsibility. There is little doubt that university and college research and postgraduate training will both continue to grow in volume and undergo rapid changes in methods and techniques in the next few years. Such developments must be matched by the growth and modification of the schemes described in this publication. The success of D.S.I.R. in supporting research has been based on a good flow of research problems, good advice on the selection of projects to support, a good supply of men and women of top quality to tackle them, adequate funds from the Exchequer, and efficient and flexible administration. If all these factors continue on a rising scale, the future success of research and training in universities and colleges is assured.

Appendix A

Department of Scientific and Industrial Research Act, 1956*

4 & 5 ELIZ. II, CH. 58

Chapter 58

An Act to make provision with respect to the Department of Scientific and Industrial Research; and for purposes connected therewith.

[2nd August, 1956]

BE it enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:

Reorganization of scientific and industrial research.

1.—(1) The Department of Scientific and Industrial Research (in this Act referred to as "the Department") shall be placed under the charge of a Council for Scientific and Industrial Research (in this Act referred to as "the Research Council") whose functions under this Act shall be exercised on behalf of the Crown and whose members shall be appointed by the Lord President of the Council after consultation with the President of the Royal Society.

(2) In the exercise of any powers or the performance of any duties conferred or imposed upon them by this Act, the Research Council shall comply with any directions which may from time to time be given to them by a Committee of the Privy Council for scientific and industrial research consisting of the Lord President of the Council and such other members as Her Majesty may from time to time appoint; and for the purposes of the Ministers of the Crown (Transfer of Functions) Act, 1946, the expression "Minister of the Crown" in that Act shall include that Committee.

9 & 10 Geo. 6. c. 31.

(3) The Research Council shall be charged with the organization, development and encouragement of scientific and of industrial research and with the dissemination of the results of such research, and without prejudice to the generality of the foregoing provisions of this subsection may in particular:—

- (*a*) encourage and support scientific research in universities, technical colleges and other institutions; and
- (*b*) establish or develop institutions or departments of institutions for investigation and research relating to the advancement of trade and industry; and
- (*c*) take steps to further the practical application of the results of scientific and of industrial research,

and may make grants for the purposes of any of their functions under this subsection; and in exercising their functions under this subsection the Research Council shall have regard, consistently with the national interest, to similar or related activities carried on by other persons.

---

* This Act came into force on 7th November 1956.

(4) The Research Council may also make grants for post-graduate instruction in science or technology.

(5) The Secretary of the Research Council (in this Act referred to as "the Secretary") shall be appointed by the Lord President of the Council after consultation with the Research Council, and the other officers and servants of the Department shall, subject to the consent of the Treasury as to number, be appointed by the Research Council; and the Secretary, officers and servants so appointed shall be paid such salaries and allowances as the Research Council may with the consent of the Treasury determine.

The Research Council.

2.—(1) The Research Council shall consist of such number of members as the Lord President of the Council may from time to time determine, and the Lord President of the Council shall from time to time appoint one of those members to act as the chairman of the Research Council; and the chairman and other members of the Research Council shall hold and vacate their offices in accordance with the terms of their respective appointments.

(2) The Research Council shall be a body corporate and shall have an official seal, which shall be authenticated by the signature of the Secretary or of a person authorized by the Secretary, with the approval of the Research Council, to act in that behalf, and which shall be officially and judicially noticed.

(3) The Research Council shall have power to enter into contracts or agreements, to acquire and hold land or any interest in land, and to do all other things necessary or convenient for the purpose of their functions under this Act; and any land or interest in land acquired by the Research Council shall be held on trust for Her Majesty for the public service:

Provided that any contract or agreement made by or on behalf of the Research Council otherwise than under seal shall be signed by the Secretary or by a person authorized by the Secretary, with the approval of the Research Council, to act in that behalf.

(4) The Research Council may appoint committees to exercise, or advise them on the exercise of, any of their functions under the foregoing section, and may appoint to any such committee persons who are not members of the Research Council, and the Research Council may also enter into arrangements for the performance of such functions on their behalf by other persons.

(5) There shall be paid to the members of the Research Council or of any committee appointed by that Council such remuneration as the Treasury may authorise.

(6) The procedure and quorum of the Research Council and any committee appointed by that Council shall be such as that Council may from time to time determine.

(7) The Research Council shall in each year send to the Committee of the Privy Council referred to in subsection (2) of the foregoing section a report of their proceedings during the preceding year, and the Lord President of the Council shall cause a copy of that report to be laid before each House of Parliament.

(8) Every document purporting to be an instrument made or issued by or on behalf of the Research Council and to be sealed with their seal authenticated in the manner provided by subsection (2), or to be signed as

mentioned in subsection (3), of this section shall be received in evidence and be deemed to be so made or issued without further proof, unless the contrary is shown.

Expenses and payments.

3.—(1) The remuneration of the members of the Research Council or of any committee appointed by that Council, the salaries and allowances of the Secretary and of the other officers and servants of the Department, and any expenditure incurred by the Research Council under this Act, shall be defrayed out of moneys provided by Parliament.

(2) Any payment by or on behalf of the Research Council under this Act shall be made through a person authorized by the Secretary, with the approval of the Research Council, to act in that behalf.

Revocations, transitional provisions, etc.

4.—(1) Any Order in Council in force immediately before the appointed day relating to the Committee of the Privy Council for scientific and industrial research and to an advisory council for the purposes of that Committee is hereby revoked, but any person serving immediately before that day as a member, the Secretary or an officer of that Committee shall be deemed to have been duly appointed in pursuance of this Act as respectively a member of the Committee of the Privy Council provided for by subsection (2) of section one of this Act, the Secretary of the Research Council, or an officer or servant of the Department.

(2) The Imperial Trust for the Encouragement of Scientific and Industrial Research is hereby dissolved, and any property vested in, rights enjoyed by, or liabilities incumbent on, that Trust immediately before the appointed day shall hereby vest in or devolve on the Research Council.

(3) Any property held for the purposes of the Department immediately before the appointed day by the Committee of the Privy Council set up under the Orders in Council referred to in subsection (1) of this section, and any rights or liabilities relating to the Department for which immediately before that day the said Committee held themselves responsible, shall hereby vest in or devolve on the Research Council.

Short title and commencement.

5.—(1) This Act may be cited as the Department of Scientific and Industrial Research Act, 1956.

(2) This Act shall come into force on such day as Her Majesty may by Order in Council appoint (in this Act referred to as "the appointed day").

Appendix B

Terms of Reference and Membership of Committees and Sub-committees: Senior Staff of Grants Division, 31st December, 1960

1. TERMS OF REFERENCE AT 31st DECEMBER 1960

(i) Postgraduate Training Awards Committee

GENERALLY to advise the Council, as required from time to time and as the Committee may themselves wish, on the Department's arrangements and desirable resources for making awards to postgraduate students and in particular:

(a) on the Council's behalf, and subject to such general principles and financial and numerical limitations as the Council may prescribe from time to time, to recommend to the Secretary of the Department:

  (i) what grants shall be awarded in response to applications for Research Studentships for postgraduate training in research in science and technology and for Advanced Course Studentships for postgraduate courses of instruction in science and technology;

  (ii) what awards shall be made in response to applications for Research Fellowships to enable young investigators of exceptional promise and proved capacity to devote their whole time to original research in science or technology;
  provided that the Chairman of the Committee may, in any case in which he considers it necessary, require that a particular conclusion be referred to the full Council for further consideration and endorsement before becoming effective.

(b) to report to the Council from time to time, and not less than annually, on the awards they have recommended.

(ii) Sub-committees of the Postgraduate Training Awards Committee

TO TENDER such advice to the Postgraduate Training Awards Committee as is required from time to time.

(iii) Research Grants Committee

GENERALLY to advise the Council, as required from time to time, and as the Committee may themselves wish, on the Department's arrangements and desirable resources for financially assisting researches in science and technology, not otherwise provided for, at universities, technical colleges and other institutions, and in particular:

(a) on the Council's behalf to recommend to the Secretary of the Department the amount of grant, if any, to be awarded in response to individual applications, subject to such general principles and such financial limitations as the Council may prescribe from time to time, provided that in the case of any proposal by the Committee to award a grant which would exceed £5000 or in any other case in which the Chairman of the Committee may consider it necessary, the Committee's conclusion shall be referred to the full Council for further consideration and endorsement before becoming effective;

(b) to report to the Council from time to time, and not less than annually, on the awards they have recommended.

(iv) Sub-committees of the Research Grants Committee

(i) TO SURVEY the research in science or technology within the field of the Sub-committee being undertaken in universities and elsewhere in the U.K. and to advise the Research Grants Committee on any lines of investigation particularly worthy of financial support from D.S.I.R.

(ii) On the Council's behalf to recommend to the Secretary of the Department the amount of grant, if any, towards assisting researches in science or technology within the field of the Sub-committee, to be awarded in response to individual applications, subject to such general principles and such financial limitations as the Council or the Research Grants Committee may prescribe from time to time, including a limited aggregate to each Sub-committee for each financial year to be determined by the Research Grants Committee provided that in the case of any proposal by a Sub-committee to award a grant which would exceed £3000 or in any other case in which the Chairman of the Sub-committee may consider it necessary the Sub-committee's conclusion shall be referred to the Research Grants Committee for further consideration and endorsement or similar reference to the Research Council before becoming effective.

(iii) To report to the Research Grants Committee from time to time and not less than annually on the awards they have recommended.

(v) Human Sciences Committee

WHEN the Human Sciences Committee was set up in 1957 its terms of reference were:

Generally, to keep under review the development of the human sciences in relation to industrial needs and to advise the Council, as required from time to time, and as the Committee may themselves wish, on the Department's arrangements and desirable resources for promoting, by financial assistance or otherwise, researches within that field.

In particular:

(a) To submit annually a broad programme of research.

(b) On the Council's behalf to recommend to the Secretary of the Department the amounts to be expended on contracts or grants for or in support of researches within the general programme approved by the Council, and subject to such general principles and financial limitations as the Council may prescribe from time to time, provided that in the case of any proposal by the Committee to award a grant which would exceed £5000 in all or £2000 in any one financial year, or in any other case in which the Chairman of the Committee may consider it necessary, the Committee's conclusion shall be referred to the full Council for further consideration and endorsement before becoming effective.

(c) To consider and advise upon the progress of investigations undertaken by or with the support of the Department in this field and to report to the Council thereon from time to time, and not less than annually.

In consequence of the reorganization of the responsibilities for the Human Sciences within D.S.I.R. the terms of reference of the Committee were amended in July 1959 to read as follows:

1. Generally, to keep under review the development of the human sciences in relation to industrial needs and to advise the Council, as instructed by the Council from time to time, on the Department's activities within that field.

2. Within these terms of reference they shall, in consultation with such other committees of the Department as may be concerned:

(a) Consider and advise upon the progress of work undertaken by or with the support of the Department in this field and report to the Council thereon from time to time;

(b) advise the Council on the desirable resources for promoting research in this field by means of grants to universities and other bodies;

(c) on the Council's behalf, recommend to the Secretary of the Department the amounts to be expended on particular grants for special researches, subject to such general principles and financial limitations as the Council may prescribe from time to time, provided that in the case of any proposal by the Committee to award a grant which would exceed £5000 in all or £2000 in any one financial year, or in any other case in which the Chairman of the Committee may consider it necessary, the Committee's conclusion shall be referred to the Council for further consideration and endorsement before becoming effective.

(vi) Sub-committees of the Human Sciences Committee

ERGONOMICS SUB-COMMITTEE

(a) Generally, in relation to issues within the terms of reference of the Human Sciences Committee, to keep under review:
  (i) the present situation and development in ergonomics;
  (ii) existing research and research needs in ergonomics;
  (iii) effective dissemination of ergonomics research results to industry.

(b) In particular:
  (i) To survey the research in ergonomics being undertaken in universities, colleges and other institutions in the U.K., and to advise the Human Sciences Committee on any lines of investigation particularly worthy of financial support from D.S.I.R.;
  (ii) to advise the Human Sciences Committee on any action which needs to be taken in order to further the effective development and application of ergonomics.

E.P.A. SUB-COMMITTEE

To consider such E.P.A. matters as fall within the responsibility of the Human Sciences Committee and to report from time to time.

GRANTS SUB-COMMITTEE

To consider applications for Research Grants on behalf of the Human Sciences Committee and to make recommendations to the main Committee.

WORK STUDY SUB-COMMITTEE (dissolved December, 1959)

(a) Generally in relation to problems within the interest of the Human Sciences Committee, to keep under review:
  (i) The present situation and developments in work study;
  (ii) the reasons for the effects of work study applications;
  (iii) existing research and research needs in this field;
  (iv) the effective dissemination of research results to industry.

(b) In particular:
  (i) To recommend for the consideration of the Human Sciences Committee specific research projects which, in the opinion of the Sub-committee, should be initiated or stimulated;
  (ii) to consider and advise upon the progress of any individual work study project which is carried out under the auspices of the Human Sciences Committee.

2. MEMBERSHIP OF ADVISORY COUNCIL, RESEARCH COUNCIL, COMMITTEES AND SUB-COMMITTEES

(i) Advisory Council (1st October 1956 to 6th November 1956) and Council for Scientific and Industrial Research—D.S.I.R. Research Council (7th November 1956[*] to 31st December 1960)

	Period of Membership
Sir Harry Jephcott, D.Sc., F.R.I.C., F.P.S. (*Chairman of Glaxo Laboratories Ltd.*)	Chairman, Advisory Council, from 12.5.56, and Chairman, Research Council, from 7.11.56
Sir Eric Ashby, M.A., D.Sc., Sc.D., LL.D., D.Litt., D.I.C. (Master of Clare College, Cambridge, and previously Vice-Chancellor of the Queen's University, Belfast)	To 30.9.60
Professor C. E. H. Bawn, C.B.E., Ph.D., F.R.S. (Grant Brunner Professor of Inorganic and Physical Chemistry in the University of Liverpool)	From 7.11.60
Sir Hugh Beaver, K.B.E., M.I.C.E., M.I.Chem.E., M.E.I.C., F.S.A., F.R.Econ.S., F.S.S., F.R.S.A.I. (At that time Director, Colonial Development Corporation)	Chairman, Advisory Council, to 11.5.56, and Member, Research Council, to 23.11.56
Professor P. M. S. Blackett, M.A., D.Sc., Sc.D., LL.D., F.R.S. (Pro Rector and Head of the Department of Physics, Imperial College of Science and Technology, London)	To 30.9.60
Professor B. Bleaney, M.A., D.Phil., F.R.S. (Dr. Lee's Professor of Experimental Philosophy in the University of Oxford)	From 1.10.60
Professor C. F. Carter, M.A. (Stanley Jevons' Professor of Political Economy in the University of Manchester)	From 1.11.59
J. W. Cook, Esq., Ph.D., D.Sc., Sc.D., F.R.I.C., F.R.S. (Vice-Chancellor of the University of Exeter)	From 1.10.60
F. Cousins, Esq. (General Secretary, Transport and General Workers' Union)	From 1.11.60
Sir Harold Roxbee Cox,[†] Ph.D., D.Sc., D.I.C., M.I.Mech.E., F.R.Ae.S. (Chairman of the National Council for Technological Awards and Chairman of Metal Box Ltd.)	From 1.6.57
W. Douglass, Esq. (Member of the Industrial Court)	To 30.9.60
Sir Walter Drummond, D.C.L., M.I.C.E., M.I.Mech.E. (Chairman of the Geological Survey Board)	From 7.11.56

---

[*] The date the D.S.I.R. Act, 1956, came into force

[†] Chairman of The Research Council since 1.10.61.

K

	Period of Membership
W. L. Heywood, Esq., O.B.E. (Secretary, National Union of Dyers, Bleachers and Textile Workers)	To 31.12.57
Professor Sir Willis Jackson,* D.Phil., D.Eng., D.Sc., D.Sc.(Tech.), M.I.E.E., M.I.Mech.E., F.Inst.P., F.I.R.E., F.R.S. (At that time a Director of Associated Electrical Industries Ltd.)	From 7.11.56
Sir Philip Johnson, D.Sc. (Chairman of the Parsons and Marine Engineering Turbine Research and Development Association)	From 30.9.57
Vice-Admiral Sir Frank Mason, K.C.B., M.I.Mech.E., M.I.Mar.E. (Chairman, Steering Committee, National Engineering Laboratory; Member of the Governing Body, National Council for Technological Awards)	From 1.10.58
Professor E. A. G. Robinson, C.M.G., O.B.E., M.A., F.B.A. (Professor of Economics, University of Cambridge)	To 30.9.59
C. J. Smithells, Esq., M.C., D.Sc., F.I.M. (Managing Director, Magnesium Elektron Ltd., London)	From 1.6.57
Lewis T. Wright, Esq. (General Secretary, Amalgamated Weavers' Association)	From 1.1.58
Sir Harry Melville, K.C.B., Ph.D., D.Sc., LL.D., F.R.I.C., F.R.S. (Secretary to the Research Council and to the Department of Scientific and Industrial Research)	From 27.8.56

(ii) Postgraduate Training Awards Committee and its Sub-Committees (1st October 1956 to 31st December 1960)

A. POSTGRADUATE TRAINING AWARDS COMMITTEE (STYLED POSTGRADUATE TRAINING GRANTS COMMITTEE UNTIL DECEMBER 1959)

Sir Eric Ashby, M.A., D.Sc., Sc.D., LL.D., D.Litt., D.I.C.†‡ (Master of Clare College, Cambridge, and previously Vice-Chancellor of the Queen's University, Belfast)	Chairman to 30.9.60
J. W. Cook, Esq., Ph.D., D.Sc., Sc.D., F.R.I.C., F.R.S.‡ (Vice-Chancellor of the University of Exeter)	Member from 1.10.59 Chairman from 1.10.60
Professor C. E. H. Bawn, C.B.E., Ph.D., F.R.S.‡ (Grant Brunner Professor of Chemistry in the University of Liverpool)	From 1.10.60

---

* Since 1st October 1961, Head of The Department of Electrical Engineering at the Imperial College of Science and Technology, London.

† Member of the Advisory Council between 1.10.56 and 6.11.56.

‡ Member of the Research Council between 7.11.56 and 31.12.60.

	Period of Membership
Professor P. M. S. Blackett, M.A., D.Sc., Sc.D., LL.D., F.R.S.[*][†] (Pro Rector and Head of the Department of Physics, Imperial College of Science and Technology, London)	To 30.9.60
Professor F. M. Bruce, M.Sc., Ph.D., M.I.E.E., A.Inst.P. (Head of the Department of Electrical Engineering, Royal College of Science and Technology, Glasgow)	From 1.10.58
D. G. Christopherson, Esq., O.B.E., D.Phil., Ph.D., M.I.Mech.E., F.R.S. (Warden of the Durham Colleges, University of Durham)	From 1.10.60
Sir Harold Roxbee Cox, Ph.D., D.Sc., D.I.C., M.I.Mech.E., F.R.Ae.S.[†][‡] (Chairman of the National Council for Technological Awards and Chairman of Metal Box Co. Ltd.)	From 1.10.60
Professor P. V. Danckwerts, G.C., M.B.E., M.A. (Shell Professor of Chemical Engineering in the University of Cambridge)	From 1.10.60
Professor J. Drever, M.A., F.B.Ps.S. (Head of the Department of Psychology, University of Edinburgh)	To 30.9.60
Professor G. C. Drew, M.A., F.B.Ps.S. (Head of the Department of Psychology, University College, London)	From 1.10.60
J. S. Fulton, Esq., M.A. (Vice-Chancellor of the University of Sussex and previously Principal of the University College of Swansea)	From 1.10.56
Professor E. L. Hirst, C.B.E., M.A., D.Sc., LL.D., F.R.I.C., F.R.S. (Professor of Organic Chemistry, University of Edinburgh)	From 1.10.57
D. G. James, Esq., M.A., LL.D. (Vice-Chancellor of the University of Southampton)	To 30.9.59
Professor R. V. Jones, C.B., C.B.E., M.A., D.Phil., F.Inst.P. (Head of the Department of Natural Philosophy, University of Aberdeen)	To 30.9.57
Professor J. A. L. Matheson, M.B.E., M.Sc., Ph.D., M.I.C.E. (At that time Beyer Professor of Engineering in the University of Manchester)	To 30.9.59
Sir Charles Morris, M.A., LL.D., D.Litt. (Vice-Chancellor of the University of Leeds)	From 1.10.56

---

[*] Member of the Advisory Council between 1.10.56 and 6.11.56.
[†] Member of the Research Council between 7.11.56 and 31.12.60.
[‡] Chairman of The Research Council since 1.10.61.

	Period of Membership
Professor F. Morton, Ph.D., D.Sc., M.I.Chem.E., F.R.I.C. (Head of the Department of Chemical Engineering, Fuel Technology and Metallurgy, Manchester College of Science and Technology)	To 30.9.60
Professor A. Porter, M.Sc., Ph.D., A.M.I.E.E. (Recently Professor of Light Electrical Engineering, Imperial College of Science and Technology, London)	To 30.9.58
Professor Sir Alfred Pugsley, O.B.E., D.Sc., M.I.C.E., F.R.Ae.S., F.R.S. (Head of the Department of Civil Engineering, University of Bristol)	From 1.10.59
Professor L. Rosenhead, C.B.E., Ph.D., D.Sc., F.R.S. (Head of the Department of Applied Mathematics, University of Liverpool)	To 30.9.58
Professor F. W. Shotton, M.B.E., M.A., Sc.D., F.R.S. (Head of the Department of Geology, University of Birmingham)	From 1.10.59
Professor J. E. Smith, M.A., Pb.D., Sc.D., F.R.S. (Head of the Department of Zoology, Queen Mary College, London)	From 1.10.58
Professor F. S. Spring, Ph.D., D.Sc., F.R.S. (Recently Freeland Professor of Chemistry in the Royal College of Science and Technology, Glasgow)	To 30.9.57
Professor E. C. Stoner, Sc.D., F.Inst.P., F.R.S. (Cavendish Professor of Physics in the University of Leeds)	From 1.10.57
Professor G. Temple, C.B.E., M.A., Ph.D., D.Sc., F.R.Ae.S., F.R.S. (Sedleian Professor of Natural Philosophy in the University of Oxford)	From 1.10.58
Professor C. E. Tilley, Ph.D., D.Sc., F.R.S. (Recently Head of the Department of Mineralogy and Petrology, University of Cambridge)	To 30.9.59
Professor G. C. Varley, M.A., Ph.D. (Hope Professor of Entomology in the University of Oxford)	To 30.9.58
P. F. R. Venables, Esq., Ph.D., F.R.I.C. (Principal, Birmingham College of Advanced Technology)	From 1.10.56
The Chairman of the University Grants Committee (Sir Keith Murray, B.Sc., Ph.D., M.A., B.Litt.)	From 1.10.56
A representative of the Ministry of Education	
(D. A. Routh, Esq.	To November 1956
A. R. M. Maxwell-Hyslop, Esq.)	From March 1957

B. SUB-COMMITTEES FOR STUDENTSHIPS AND FELLOWSHIPS 1957 TO 1960

(a) *Biology and Biochemistry*

Professor G. C. Varley, M.A., Ph.D. (Hope Professor of Entomology in the University of Oxford)	Chairman 1957–1958

	Period of Membership
Professor J. E. Smith, M.A., Ph.D., Sc.D., F.R.S. (Head of the Department of Zoology, Queen Mary College, London)	Member from 1957 Chairman from 1959
Professor J. E. Harris, C.B.E., M.A., Ph.D., F.R.S. (Head of the Department of Zoology, University of Bristol)	From 1959
Professor A. R. Clapham, M.A., Ph.D., F.R.S. (Head of the Department of Botany, University of Sheffield)	1960
Professor H. E. Street, Ph.D., D.Sc. (Head of the Department of Botany, University College of Swansea)	1957–1959
Professor M. M. Swann, M.A., Ph.D. (Head of the Department of Natural History and Zoology, University of Edinburgh)	From 1959
Professor M. Thomas, M.A., F.R.S. (Recently Head of the Department of Botany, King's College, Newcastle)	1957–1959
Professor D. H. Valentine, M.A., Ph.D., F.L.S. (Head of the Department of Botany, Durham Colleges)	1960
Professor C. M. Yonge, C.B.E., Ph.D., D.Sc., F.R.S. (Regius Professor of Zoology, University of Glasgow)	From 1957–1958
Professor F. G. Young, M.A., Ph.D., D.Sc., F.R.I.C., F.R.S. (Sir William Dunn Professor of Biochemistry in the University of Cambridge)	From 1957
(b) *Chemical Engineering and Metallurgy*	
Professor F. Morton, Ph.D., D.Sc., M.I.Chem.E., F.R.I.C. (Head of the Department of Chemical Engineering, Fuel Technology and Metallurgy, Manchester College of Science and Technology)	Chairman from 1957
Professor J. M. Coulson, M.A., Ph.D. (Head of the Department of Chemical Engineering, King's College, Newcastle)	1957–1958
Professor J. W. Cuthbertson, D.Sc., F.I.M. (Cripps Professor of Metallurgy in the University of Nottingham)	From 1957
Professor C. W. Dannatt, D.I.C., F.R.I.C. (At that time Head of the Department of Metallurgy, Imperial College of Science and Technology, London)	1957–1959
Professor K. G. Denbigh, M.A., Ph.D., D.Sc., F.R.I.C. (Professor of Chemical Engineering Science, Imperial College of Science and Technology, London)	From 1957
Professor N. J. Petch, Ph.D., D.Met. (William Cochrane Professor of Metallurgy in King's College, Newcastle)	From 1959

	Period of Membership
Professor A. G. Quarrell, D.Sc., Ph.D., F.Inst.P., F.I.M. (Head of the Department of Metallurgy, University of Sheffield)	1957–1959
Professor E. S. Sellers, M.Sc., M.A. (At that time Head of the Department of Chemical Engineering, University College of Swansea)	From 1959
S. R. Tailby, Esq., Ph.D., F.R.I.C., M.I.Chem.E. (Head of the Department of Chemical Engineering, Battersea College of Technology)	1960
(c) *Chemistry*	
Professor F. S. Spring, Ph.D., D.Sc., F.R.S. (At that time Freeland Professor of Chemistry in the Royal College of Science and Technology, Glasgow)	Chairman 1957
Professor E. L. Hirst, C.B.E., M.A., D.Sc., LL.D., F.R.I.C., F.R.S. (Professor of Organic Chemistry, University of Edinburgh)	Member from 1957 Chairman from 1958
Professor C. E. H. Bawn, C.B.E., Ph.D., F.R.S.* (Grant Brunner Professor of Chemistry in the University of Liverpool)	1957
Professor F. S. Dainton, M.A., Sc.D., F.R.I.C., F.R.S. (Head of the Department of Physical Chemistry, University of Leeds)	1957–1958
Professor A. G. Evans, Ph.D., D.Sc., F.R.I.C. (Head of the Department of Chemistry, University College of South Wales and Monmouthshire, Cardiff)	1957–1959
Professor D. H. Everett, M.B.E., M.A., D.Phil., D.Sc. (Leverhulme Professor of Inorganic and Physical Chemistry in the University of Bristol)	From 1959
Professor R. N. Haszeldine, M.A., Ph.D., D.Sc., Sc.D., F.R.I.C. (Head of the Department of Chemistry, Manchester College of Science and Technology)	From 1959
Professor R. D. Haworth, B.Sc., Ph.D., D.Sc., F.R.I.C., F.R.S. (Firth Professor of Chemistry in the University of Sheffield)	From 1958
Professor E. D. Hughes, Ph.D., D.Sc., F.R.I.C., F.R.S. (Head of the Department of Chemistry, University College, London)	From 1958
Professor E. R. H. Jones, M.A., Ph.D., D.Sc., F.R.I.C., F.R.S. (Waynflete Professor of Organic Chemistry in the University of Oxford)	1960
W. G. S. Parker, Esq., Ph.D., F.R.I.C. (Head of the Department of Chemistry, Birmingham College of Advanced Technology)	From 1959

---

* Member of the Research Council between 7.11.56 and 31.12.60.

	Period of Membership
L. P. Priestley, Esq., B.Sc., F.R.I.C. (Head of the Department of Chemistry, Leicester College of Technology and Commerce)	1958
G. R. Ramage, Esq., Ph.D., D.Sc., F.R.I.C. (Head of Department of Chemistry and Applied Chemistry, Royal Technical College, Salford)	1959
L. E. Sutton, Esq., M.A., D.Phil., F.R.S. (Department of Physical Chemistry, Oxford)	1958–1959
Professor Lord Todd, M.A., D.Sc., LL.D., Dr. Rer. Nat., D.Phil., Dr. Phil., F.R.I.C., F.R.S. (Chairman of the Advisory Council on Scientific Policy, and Head of the Department of Chemistry, University of Cambridge)	From 1957
G. E. Watts, Esq., M.A., Ph.D., B.Sc., F.R.I.C. (Principal of Brighton Technical College)	1957
(d) *Electrical Engineering*	
Professor A. Porter, M.Sc., Ph.D., A.M.I.E.E. (Recently Professor of Light Electrical Engineering, Imperial College of Science and Technology, London)	Chairman 1957–1958
Professor F. M. Bruce, M.Sc., Ph.D., M.I.E.E., A.Inst.P. (Head of the Department of Electrical Engineering, Royal College of Science and Technology, Glasgow)	Member from 1957 Chairman from 1959
Professor H. E. M. Barlow, Ph.D., M.I.E.E., F.R.S. (Pender Professor of Electrical Engineering in the University College, London)	From 1957
Professor E. G. Cullwick, O.B.E., M.A., D.Sc. (Watson Watt Professor of Electrical Engineering in the University of St. Andrews)	1957–58
Professor W. Fishwick, M.A., Ph.D. (Head of the Department of Electrical Engineering, University College of Swansea)	From 1959
P. F. Soper, Esq., Ph.D., M.I.E.E. (Head of the Department of Electrical Engineering, Northampton College of Advanced Technology, London)	1960
Professor D. G. Tucker, D.Sc. (Head of the Department of Electrical Engineering, University of Birmingham)	1959
Professor A. Tustin, M.Sc., M.I.E.E. (Head of the Department of Heavy Electrical Engineering, Imperial College of Science and Technology, London)	1959
Professor F. C. Williams, C.B.E., D.Phil., D.Sc., M.I.E.E., F.R.S. (Edward Stocks Massey Professor of Electro-Technics in the University of Manchester)	1957–1958
Professor E. E. Zepler, D.Phil., Ph.D. (Head of the Department of Electronics, University of Southampton)	From 1959

	Period of Membership
(e) *Engineering*	
Professor J. A. L. Matheson, M.B.E., Ph.D., M.Sc., M.C.E., M.I.C.E. (At that time Beyer Professor of Engineering in the University of Manchester)	Chairman 1957–1959
Professor Sir Alfred Pugsley, O.B.E., D.Sc., M.I.C.E., F.R.Ae.S., F.R.S. (Head of the Department of Civil Engineering, University of Bristol)	Member from 1957 Chairman 1960
Professor Sir John Baker, O.B.E., D.Sc., Sc.D., M.I.C.E., F.R.S. (Head of the Department of Engineering, University of Cambridge)	From 1959
Professor L. J. Kastner, M.A., M.Sc., M.I.Mech.E. (Head of the Department of Mechanical Engineering, King's College, London)	From 1959
Professor J. C. Mitcheson, C.B.E., B.Sc. (Dean of the Royal School of Mines, Imperial College of Science and Technology, London)	1957
Professor J. A. Pope, B.Sc., Ph.D., D.Sc. (At that time Head of the Department of Mechanical Engineering, University of Nottingham)	1957–1958
Professor E. L. J. Potts, M.Sc. (Milburn Professor of Mining Engineering, King's College, Newcastle)	From 1958
Professor E. J. Richards, O.B.E., M.A., D.Sc. (Head of the Department of Aeronautics and Astronautics, University of Southampton)	1960
(f) *Geology*	
Professor C. E. Tilley, Ph.D., D.Sc., F.R.S. (At that time Head of the Department of Mineralogy and Petrology, University of Cambridge)	Chairman 1957–1959
Professor F. W. Shotton, M.B.E., M.A., Sc.D., F.R.S. (Head of the Department of Geology, University of Birmingham)	Member from 1958 Chairman 1960
Professor T. N. George, Ph.D., D.Sc., Des.Sc. (Head of the Department of Geology, University of Glasgow)	From 1957
Professor Sir William Pugh, O.B.E., D.Sc., F.R.S. (At that time Director of the Geological Survey and Museum)	1957–1958
Professor J. A. Steers, M.A. (Head of the Department of Geography, University of Cambridge)	1960
Professor W. F. Whittard, Ph.D., D.Sc. (C. Wills Professor of Geology in the University of Bristol)	1960
Professor D. Williams, Ph.D., D.Sc., B.Eng., D.I.C. (Head of the Department of Geology, Imperial College of Science and Technology, London)	1957 and from 1959

	Period of Membership
(g) *Human Sciences*	
Professor J. Drever, M.A. (Head of the Department of Psychology, University of Edinburgh)	Chairman from 1957
Professor A. K. Cairncross, C.M.G., M.A., Ph.D. (At that time Head of the Department of Social and Economic Research, University of Glasgow)	1957
Professor D. V. Glass, B.Sc.(Econ.), Ph.D. (Martin White Professor of Sociology, London School of Economics and Political Science)	1960
Professor L. S. Hearnshaw, M.A. (Head of the Department of Psychology, University of Liverpool)	From 1959
Professor W. J. M. Mackenzie, LL.B., M.A. (Head of the Department of Government, University of Manchester)	1957–1959
Professor A. Rodger, M.A. (Professor of Occupational Psychology, Birkbeck College, London)	1957–1959
Professor W. J. H. Sprott, M.A. (Head of the Department of Psychology, University of Nottingham)	1957–1959
Professor B. R. Williams, B.A., M.A. (Robert Ottley Professor of Economics in the University of Manchester)	From 1958
(h) *Mathematics*	
Professor L. Rosenhead, C.B.E., Ph.D., D.Sc., F.R.S. (Head of the Department of Applied Mathematics, University of Liverpool)	Chairman to 1958
Professor G. F. J. Temple, C.B.E., M.A., Ph.D., D.Sc., F.R.Ae.S., F.R.S. (Sedleian Professor of Natural Philosophy in the University of Oxford)	Member from 1958 Chairman from 1959
Dr. Mary L. Cartwright, D.Phil., LL.D., D.Sc., Sc.D., F.R.S. (Mistress of Girton College and Reader in Mathematics, University of Cambridge)	From 1958
Professor E. T. Copson, M.A., D.Sc. (Regius Professor of Mathematics in the University of St. Andrews)	1959
Professor H. Davenport, M.A., Sc.D., F.R.S. (Rouse Ball Professor of Mathematics in the University of Cambridge)	1957–1958
Professor R. L. Goodstein, Ph.D., M.Sc., D.Litt. (Head of the Department of Mathematics, University of Leicester)	From 1959
Professor A. E. Green, M.A., Ph.D., Sc.D., F.R.S. (Head of the Department of Applied Mathematics, King's College, Newcastle)	1957
Professor J. C. Gunn, M.A. (Cargill Professor of Natural Philosophy in the University of Glasgow)	1959

	Period of Membership
Professor Sir William Hodge, Hon.D.Sc., Sc.D., F.R.S. (Lowndean Professor of Astronomy and Geometry in the University of Cambridge)	1957
Professor M. J. Lighthill, M.Sc., F.R.S. (At that time Beyer Professor of Applied Mathematics in the University of Manchester)	1957
Professor M. H. A. Newman, M.A., M.Sc., F.R.S. (Fielden Professor of Pure Mathematics in the University of Manchester)	From 1958
Professor R. E. Peierls, C.B.E., M.A., D.Phil., D.Sc., M.Sc., F.R.S. (Head of the Department of Mathematical Physics, University of Birmingham)	1958
Professor M. H. L. Pryce, M.A., Ph.D., F.R.S. (H. O. Wills Professor of Physics in the University of Bristol)	1957
Professor A. Salam, M.A., Ph.D., F.R.S. (Professor of Theoretical Physics, Imperial College of Science and Technology, London)	1960
Professor J. G. Semple, M.A., Ph.D. (Professor of Mathematics, King's College, London)	From 1959
Professor I. N. Sneddon, M.A., D.Sc. (Simson Professor of Mathematics in the University of Glasgow)	1957–1958 and 1960

(i) *Physics*

Professor R. V. Jones, C.B., C.B.E., M.A., D.Phil., F.Inst.P. (Head of the Department of Natural Philosophy in the University of Aberdeen)	Chairman 1957
Professor E. C. Stoner, Sc.D., F.Inst.P., F.R.S. (Cavendish Professor of Physics in the University of Leeds)	Chairman from 1958
Professor C. C. Butler, Ph.D., F.R.S. (Professor of Physics, Imperial College of Science and Technology, London)	From 1957
Professor G. K. T. Conn, M.A., Ph.D. (Head of the Department of Physics, University of Exeter)	From 1959
Professor P. I. Dee, C.B.E., M.A., F.Inst.P., F.R.S. (Head of the Department of Natural Philosophy, University of Glasgow)	From 1957
Professor F. C. Frank, O.B.E., D.Phil., D.Sc., F.R.S. (Professor of Physics, University of Bristol)	1957–1958
Professor F. Llewellyn Jones, M.A., D.Phil., D.Sc., F.Inst.P. (Head of the Department of Physics, University College of Swansea)	From 1959
Professor G. O. Jones, M.A., Ph.D. (Professor of Physics, Queen Mary College, London)	1957–1958

	Period of Membership
Professor H. S. Lipson, D.Sc., M.A., M.Sc., F.Inst.P., F.R.S. (Head of the Department of Physics, University of Manchester)	From 1959
Professor Sir Nevill Mott, M.A., D.Sc., F.R.S. (Cavendish Professor of Experimental Physics, University of Cambridge)	1957–1958
Professor C. F. Powell, M.A., Ph.D., Sc.D., F.R.S. (Melville Wills Professor of Physics in the University of Bristol)	1960
D. Shoenberg, Esq., M.B.E., Ph.D., F.R.S. (Reader in Physics, University of Cambridge)	1960
Professor D. H. Wilkinson, Ph.D., M.A., F.R.S. (Professor of Experimental Physics, University of Oxford)	1957–1959

(j) *Sub-committee for Advanced Courses* (1957 *to* 1959)

P. F. R. Venables, Esq., Ph.D., F.R.I.C. (Principal, Birmingham College of Advanced Technology)	Chairman 1957–1959
Professor A. L. L. Baker, D.Sc., M.I.C.E. (Professor of Concrete Structures and Technology, Imperial College of Science and Technology, London)	1957–1959
B. V. Bowden, Esq., M.A., Ph.D., M.I.E.E. (Principal, Manchester College of Science and Technology)	1957–1958
Professor A. R. Collar, M.A., D.Sc., F.R.Ae.S. (Sir George White Professor of Aeronautical Engineering in the University of Bristol)	1957–1958
Professor K. C. Dunham, S.D., Ph.D., D.Sc., F.R.S. (Head of the Department of Geology, Durham Colleges)	1959
Professor F. H. Garner, O.B.E., M.Sc., Ph.D., F.R.I.C. (At that time Head of the Department of Chemical Engineering, University of Birmingham)	1958–1959
Professor L. S. Hearnshaw, M.A. (Head of the Department of Psychology, University of Liverpool)	1957–1959
Professor Sir Christopher Ingold, D.Sc., F.R.S. (Department of Chemistry, University College, London)	1957–1958
Professor W. H. Linnell, M.Sc., Ph.D., D.Sc., F.R.I.C. (Dean of the School of Pharmacy, London)	1959
Professor P. B. Moon, M.A., M.Sc., Ph.D., F.Inst.P., F.R.S. (Poynting Professor of Physics, University of Birmingham)	1959
J. S. Tait, Esq., Ph.D. (Principal, Northampton College of Advanced Technology)	1957–1959

	Period of Membership
Professor J. P. Todd, Ph.D., F.R.I.C. (Head of the Department of Pharmacy, Royal College of Science and Technology, Glasgow)	1957–1959
M. V. Wilkes, Esq., M.A., Ph.D., F.R.S. (Head of the Mathematical Laboratory, University of Cambridge)	1957–1959

(iii) Research Grants Committee and its Sub-Committees (1st October to 31st December 1960)

A. RESEARCH GRANTS COMMITTEE

Professor P. M. S. Blackett, M.A., D.Sc., Sc.D., LL.D., F.R.S.[*][†] (Dean of the Royal College of Science and Head of the Department of Physics, Imperial College of Science and Technology, London)	Chairman to 30.9.60
Professor C. E. H. Bawn, C.B.E., Ph.D., F.R.S.[†] (Grant Brunner Professor of Inorganic and Physical Chemistry in the University of Liverpool)	Chairman from 1.10.60
Sir Eric Ashby, M.A., D.Sc., Sc.D., LL.D., D.Litt., D.I.C.[*][†] (Master of Clare College, Cambridge, and lately Vice-Chancellor of the Queen's University, Belfast)	To 30.9.60
Professor B. Bleaney, M.A., D.Phil., F.R.S. (Dr. Lee's Professor of Experimental Philosophy in the University of Oxford)	From 1.10.60
Professor D. G. Catcheside, M.A., D.Sc., F.R.S. (Head of the Department of Microbiology, University of Birmingham)	From 1.10.59
Sir John Cockroft, O.M., K.C.B., C.B.E., M.A., M.Sc.(Tech.), Ph.D., D.Sc., Sc.D., LL.D., M.I.E.E., M.I.Mech.E., F.R.S. (Master of Churchill College, Cambridge, and member (part-time) of the United Kingdom Atomic Energy Authority)	From 1.10.56
J. W. Cook, Esq., Ph.D., D.Sc., Sc.D., F.R.I.C., F.R.S.[†] (Vice-Chancellor of the University of Exeter)	From 1.10.60
Professor A. H. Cottrell, M.A., Ph.D., F.R.S. (Goldsmiths' Professor of Metallurgy in the University of Cambridge)	From 1.10.59
S. C. Curran, Esq., D.Sc., F.R.S. (Principal of the Royal College of Science and Technology, Glasgow)	From 1.10.60
Professor Sir Charles Dodds, M.V.O., Ph.D., D.Sc., Sc.D., M.D., F.R.C.P., F.R.I.C., F.R.S.E., F.R.S.[†] (Head of the Department of Biochemistry, Middlesex Hospital Medical School)	To 30.9.60

---

[*] Member of The Advisory Council between 1.10 56 and 6.11.56.

[†] Member of The Research Council between 7.11.56 and 31.12.60.

	Period of Membership
Professor H. Ford, Ph.D., D.Sc.(Eng.), M.I.Mech.E., M.I.C.E. (Professor of Applied Mechanics, Imperial College of Science and Technology, London)	From 1.10.56
Professor G. Gee, C.B.E., M.Sc., Ph.D., Sc.D., F.R.S. (Sir Samuel Hall Professor of Chemistry in the University of Manchester)	To 30.9.59
Professor Sir Cyril Hinshelwood, O.M., M.A., Sc.D., D.Sc., LL.D., D.C.L., F.R.I.C., F.R.S. (Dr. Lee's Professor of Physical Chemistry in the University of Oxford)	From 22.3.57
Professor A. L. Hodgkin, M.A., Sc.D., F.R.S. (Royal Society Professor in the University of Cambridge)	To 30.9.59
Professor L. Howarth, O.B.E., M.A., Ph.D., F.R.Ae.S., F.R.S. (Head of the Department of Applied Mathematics, University of Bristol)	From 1.10.60
Professor F. Hoyle, M.A., F.R.S. (Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge)	From 1.10.59
Professor Sir Willis Jackson, D.Phil., D.Eng., D.Sc., D.Sc.(Tech.), M.I.Mech.E., M.I.E.E., F.Inst.P., F.R.S.*† (At that time a Director of Associated Electrical Industries Ltd.)	From 1.10.56
Professor E. R. H. Jones, M.A., Ph.D., D.Sc., F.R.I.C., F.R.S. (Waynflete Professor of Organic Chemistry in the University of Oxford)	From 1.10.59
Professor Sir Harrie Massey, M.Sc., Ph.D., D.Sc., LL.D., F.R.S. (Quain Professor of Physics, University College, London)	From 28.1.59
Professor W. T. J. Morgan, Ph.D., D.Sc., F.R.I.C., F.R.S. (Professor of Biochemistry, The Lister Institute of Preventive Medicine, London)	From 1.10.60
Professor Sir Nevill Mott, M.A., D.Sc., F.R.S. (Cavendish Professor of Experimental Physics in the University of Cambridge)	To 30.9.60
Professor M. H. A. Newman, M.A., M.Sc., F.R.S. (Fielden Professor of Pure Mathematics in the University of Manchester)	To 30.9.60
The late Professor Sir Francis Simon, C.B.E., F.R.S. (Formerly Professor of Thermodynamics, University of Oxford)	To 29.10.56
Sir Gordon Sutherland, Sc.D., F.R.S. (Director of the National Physical Laboratory, Teddington)	From 1.10.59

---

* Member of the Research Council between 7.11.56 and 31.12.60.

† Since 1st October, 1961, Head of the Department of Electrical Engineering at the Imperial College of Science and Technology, London.

	Period of Membership
Professor Lord Todd, M.A., D.Phil., D.Sc., D.S.C., LL.D., F.R.I.C., F.R.S. (Chairman of the Advisory Council on Scientific Policy, and Head of the Department of Organic Chemistry, University of Cambridge)	To 30.9.59
Professor L. R. Wager, M.A., Sc.D., F.R.S. (Head of the Department of Geology, University of Oxford)	From 1.10.59

B. SUB-COMMITTEES OF THE RESEARCH GRANTS COMMITTEE

(a) *Astronomy Sub-committee* (1st October 1958 to 31st December 1960)

Professor P. M. S. Blackett, M.A., D.Sc., Sc.D., LL.D., F.R.S.[*][†] (Pro Rector and Head of the Department of Physics, Imperial College of Science and Technology, London)	Chairman to 30.9.60
Professor F. Hoyle, M.A., F.R.S. (Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge)	Member from 1.10.58 Chairman from 1.10.60
Professor D. E. Blackwell, M.A., Ph.D. (Savilian Professor of Astronomy in the University of Oxford)	From 16.11.60
Professor H. A. Brück, D. Phil., Ph.D. (Astronomer Royal for Scotland and Regius Professor of Astronomy in the University of Edinburgh)	From 16.11.60
Professor Sir Bernard Lovell, O.B.E., M.Sc., Ph.D., F.Inst.P., F.R.S. (Professor of Radio Astronomy, University of Manchester, Director of the Nuffield Laboratories, Jodrell Bank Experimental Station)	From 1.10.58
Professor H. H. Plaskett, M.A., F.R.S. (At that time Savilian Professor of Astronomy in the University of Oxford)	To 30.9.60
Professor M. Ryle, M.A., F.R.S. (Professor of Radio Astronomy, University of Cambridge)	From 1.10.58
Dr. R. v. d. R. Woolley, M.Sc., Ph.D., F.R.S. (Astronomer Royal, Royal Greenwich Observatory)	From 1.10.58

(b) *Biology Sub-committee* (1st October 1958 to 31st December 1960)

Professor Sir Charles Dodds, M.V.O., Ph.D., D.Sc., Sc.D., M.D., F.R.C.P., F.R.I.C., F.R.S.E., F.R.S. (Head of the Department of Biochemistry, The Middlesex Hospital Medical School)	Chairman to 30.9.60
Professor Sir Lindor Brown, C.B.E., M.A., M.Sc., M.B., Ch.B., LL.D., F.R.C.P., F.R.S. (Wayneflete Professor of Physiology in the University of Oxford)	From 1.10.58

---

[*] Member of the Advisory Council between 1.10.56 and 6.11.56.

[†] Member of the Research Council between 7.11.56 and 31.12.60.

	Period of Membership
Professor D. G. Catcheside, M.A., D.Sc., F.R.S. (Head of the Department of Microbiology, University of Birmingham)	Member from 1.12.58 Chairman from 1.10.60
Professor A. L. Hodgkin, M.A., Sc.D., F.R.S. (Royal Society Professor in the University of Cambridge)	To 18.1.60
Professor W. O. James, M.A., D.Phil., F.R.S. (Head of the Department of Botany, Imperial College of Science and Technology, London)	From 1.10.60
Professor W. T. J. Morgan, Ph.D., D.Sc., F.R.I.C., F.R.S. (Professor of Biochemistry, The Lister Institute of Preventive Medicine, London)	From 1.10.58
Professor M. M. Swann, M.A., Ph.D. (Head of the Department of Natural History and Zoology, University of Edinburgh)	From 1.10.60
Dr. W. H. Thorpe, Sc.D., F.R.S. (Director of Madingley Field Station, University of Cambridge)	From 1.10.58

(c) *Chemistry Sub-committee* (1st October to 31st December 1960)

Professor C. E. H. Bawn, C.B.E., Ph.D., F.R.S. (Grant Brunner Professor of Inorganic and Physical Chemistry in the University of Liverpool)	Chairman to 30.9.60 Member from 1.10.60
Professor E. R. H. Jones, M.A., Ph.D., D.Sc., F.R.I.C., F.R.S. (Waynflete Professor of Organic Chemistry in the University of Oxford)	Chairman from 1.10.60
E. G. Edwards, Esq., Ph.D., F.R.I.C. (Principal of the Bradford Institute of Technology)	From 18.3.59
Professor G. Gee, C.B.E., M.Sc., Ph.D., Sc.D., F.R.S. (Sir Samuel Hall Professor of Chemistry in the University of Manchester)	From 1.10.58
Professor R. S. Nyholm, D.Sc., F.R.I.C., F.R.S. (Professor of Chemistry, University College, London)	From 1.10.58
Professor M. Stacey, M.A., Ph.D., D.Sc., F.R.S. (Mason Professor of Chemistry in the University of Birmingham)	From 10.11.59
Professor Lord Todd, M.A., D.Phil., D.Sc., D.S.C., LL.D., F.R.I.C., F.R.S. (Chairman of the Advisory Council on Scientific Policy and Head of the Department of Organic Chemistry, University of Cambridge)	To 30.9.59

(d) *Geology and Geophysics Sub-committee* (1st October 1958 to 31st December 1960)

Professor H. H. Read, D.Sc., A.R.C.S., F.R.S. (At that time Professor of Geology, Imperial College of Science and Technology, London)	Chairman to 30.9.60
Professor L. R. Wager, M.A., Sc.D., F.R.S. (Head of the Department of Geology, University of Oxford)	Member from 1.10.58 Chairman from 1.10.60

	Period of Membership
Professor P. M. S. Blackett, M.A., D.Sc., Sc.D., LL.D., F.R.S.*† (Pro Rector and Head of the Department of Physics, Imperial College of Science and Technology, London)	To 30.9.59
Sir Edward Bullard, M.A., Ph.D., Sc.D., F.R.S. (Head of the Department of Geophysics, University of Cambridge)	From 1.10.58
Professor K. C. Dunham, S.D., Ph.D., D.Sc., F.R.S. (Head of the Department of Geology, University of Durham)	From 1.10.58
N. L. Falcon, Esq., M.A., F.G.S., F.R.S. (Chief Geologist, British Petroleum Co. Ltd.)	From 18.11.60
Sir William Pugh, O.B.E., D.Sc., F.R.S. (At that time Director of the Geological Survey and Museum)	To 30.9.60
Professor F. W. Shotton, M.B.E., M.A., Sc.D., F.R.S. (Head of the Department of Geology, University of Birmingham)	From 1.10.58
C. J. Stubblefield, Esq., D.Sc., Ph.D., A.R.C.S., D.I.C., F.R.S. (Director of the Geological Survey and Museum, London)	From 18.11.60

(e) *Low-Temperature and Solid-State Sub-committee* (1st October 1958 to 31st December 1960)

Professor Sir Nevill Mott, M.A., D.Sc., F.R.S. (Cavendish Professor of Experimental Physics in the University of Cambridge)	Chairman to 30.9.60
Professor A. H. Cottrell, M.A., Ph.D., F.R.S. (Goldsmiths' Professor of Metallurgy in the University of Cambridge)	Member to 30.9.60 Chairman from 1.10.60
Professor B. Bleaney, M.A., D.Phil., F.R.S.† (Dr. Lee's Professor of Experimental Philosophy in the University of Oxford)	From 1.10.58
Professor F. C. Frank, O.B.E., D.Phil., F.R.S. (Professor of Physics, University of Bristol)	From 1.10.58
Professor G. O. Jones, M.A., Ph.D. (Head of the Department of Physics, Queen Mary College, London)	From 1.10.58
R. A. Smith, Esq., C.B.E., M.A., Ph.D., A.M.I.E.E., F.R.S. (Professor of Physics, University of Sheffield)	From 1.10.58
F. A. Vick, Esq., O.B.E., M.Sc., Ph.D., F.Inst.P. (Atomic Energy Research Establishment, Harwell)	From 1.10.58

(f) *Mathematics Sub-committee* (1st October 1958 to 31st December 1960)

Professor M. H. A. Newman, M.A., M.Sc., F.R.S. (Fielden Professor of Pure Mathematics in the University of Manchester)	Chairman to 30.9.60

---

* Member of the Advisory Council between 1.10.56 and 6.11.56.

† Member of the Research Council between 7.11.56 and 31.12.60.

	Period of Membership
Professor L. Howarth, O.B.E., M.A., Ph.D., F.R.Ae.S., F.R.S. (Head of the Department of Applied Mathematics, University of Bristol)	Member to 30.9.60 Chairman from 1.10.60
Professor H. Davenport, M.A., Sc.D., F.R.S. (Rouse Ball Professor of Mathematics in the University of Cambridge)	From 1.10.58
Professor J. C. Gunn, M.A. (Cargill Professor of Natural Philosophy in the University of Glasgow)	From 1.10.58
Professor D. G. Northcott, M.A., Ph.D. (Town Trust Professor of Pure Mathematics in the University of Sheffield)	From 1.10.58
Professor G. Temple, C.B.E., M.A., Ph.D., D.Sc., F.R.Ae.S., F.R.S. (Sedleian Professor of Natural Philosophy in the University of Oxford)	From 1.10.60
J. H. Wilkinson, Esq., M.A. (Mathematics Division, National Physical Laboratory)	From 1.10.58

(g) *C.E.R.N. Panel* (1st October 1956 to 31st December 1960)

The late Professor H. W. B. Skinner, M.A., Ph.D., F.R.S. (Formerly Lyon Jones Professor of Physics in the University of Liverpool)	Chairman to January, 1960
Professor C. C. Butler, Ph.D., F.R.S. (Professor of Solid State Physics, Imperial College of Science and Technology, London)	Member from 1.10.57 Chairman from 12.5.60
Professor P. M. S. Blackett, M.A., D.Sc., Sc.D., LL.D., F.R.S.*† (Pro Rector and Head of the Department of Physics, Imperial College of Science and Technology, London)	From 1.10.56
Professor P. I. Dee, C.B.E., M.A., F.Inst.P., F.R.S. (Head of the Department of Natural Philosophy, University of Glasgow)	From 1.10.56
D. W. Fry, Esq., M.Sc. (Atomic Energy Research Establishment, Harwell)	From 1.10.56
Professor Sir Harrie Massey, M.Sc., Ph.D., D.Sc., LL.D., F.R.S. (Quain Professor of Physics, University College, London)	From 1.10.56
Professor A. W. Merrison, Ph.D. (Head of the Department of Experimental Physics, University of Liverpool)	From 1.10.60
Professor P. B. Moon, M.A., M.Sc., Ph.D., F.Inst.P., F.R.S. (Poynting Professor of Physics in the University of Birmingham)	From 1.10.56

---

* Member of the Advisory Council between 1.10.56 and 6.11.56.
† Member of the Research Council between 7.11.56 and 31.12.60.

	Period of Membership
Professor R. E. Peierls, C.B.E., M.A., M.Sc., D.Phil., D.Sc., F.R.S. (Professor of Mathematical Physics, University of Birmingham)	From 1.10.58
T. G. Pickavance, Esq., Ph.D. (Director of the Rutherford Laboratory, National Institute for Research in Nuclear Science, Harwell)	From 1.10.58
Professor C. F. Powell, M.A., Ph.D., Sc.D., F.R.S. (Melville Wills Professor of Physics in the University of Bristol)	From 1.10.56
Professor G. D. Rochester, M.Sc., Ph.D., F.Inst.P., F.R.S. (Head of the Department of Physics, Durham Colleges)	From 1.10.60
G. H. Stafford, Esq., M.Sc., Ph.D. (Head of Proton Linear Accelerator Group, National Institute for Research in Nuclear Science, Harwell)	From 19.2.60
Professor D. H. Wilkinson, M.A., Ph.D., F.R.S. (Head of the Department of Experimental Physics, University of Oxford)	From 1.10.56

(h) *Nuclear Physics Sub-committee* (1st October 1956 to 31st December 1960)

Sir John Cockroft, O.M., K.C.B., C.B.E., M.A., M.Sc.(Tech.), Ph.D., D.Sc., Sc.D., LL.D., M.I.E.E., M.I.Mech.E., F.R.S. (Master of Churchill College, Cambridge, and member (part-time) of the United Kingdom Atomic Energy Authority)	Chairman from 1.10.56
Professor P. M. S. Blackett, M.A., D.Sc., Sc.D., LL.D., F.R.S.[*][†] (Pro Rector and Head of the Department of Physics, Imperial College of Science and Technology, London)	From 1.10.56
Professor C. C. Butler, Ph.D., F.R.S. (Professor of Solid State Physics, Imperial College of Science and Technology, London)	To 30.9.59 and from 12.5.60
Professor J. M. Cassels, M.A., Ph.D., F.R.S. (Lyon Jones Professor of Physics, University of Liverpool)	From 1.10.60
Professor P. I. Dee, C.B.E., M.A., F.Inst.P., F.R.S. (Head of the Department of Natural Philosophy, University of Glasgow)	To 30.9.59
Professor S. Devons, M.A., M.Sc., Ph.D., F.R.S. (At that time Langworthy Professor of Physics in the University of Manchester)	To 30.9.59
Professor N. Feather, Ph.D., F.R.S. (Head of the Department of Natural Philosophy, University of Edinburgh)	From 1.10.58 to 30.9.59
Professor B. H. Flowers, M.A., D.Sc., F.R.S. (Head of the Department of Theoretical Physics, University of Manchester)	From 1.10.59

---

[*] Member of the Advisory Council between 1.10.56 and 6.11.56.

[†] Member of the Research Council between 7.11.56 and 31.12.60.

	Period of Membership
Professor O. R. Frisch, O.B.E., M.A., D.Phil., D.Sc., F.R.S. (Jacksonian Professor of Natural Philosophy in the University of Cambridge)	To 30.9.59
D. W. Fry, Esq., M.Sc. (Atomic Energy Research Establishment, Harwell)	From 25.3.57 to 30.9.59
Professor Sir Harrie Massey, M.Sc., Ph.D., D.Sc., LL.D., F.R.S. (Quain Professor of Physics, University College, London)	From 1.10.56
Professor P. B. Moon, M.A., M.Sc., Ph.D., F.Inst.P., F.R.S. (Poynting Professor of Physics in the University of Birmingham)	To 30.9.59
T. G. Pickavance, Esq., B.Sc., Ph.D. (Director of the Rutherford Laboratory, National Institute for Research in Nuclear Science, Harwell)	From 1.10.56
Professor C. F. Powell, M.A., Ph.D., Sc.D., F.R.S. (Melville Wills Professor of Physics in the University of Bristol)	To 30.9.59
Professor G. D. Rochester, M.Sc., Ph.D., F.Inst.P., F.R.S. (Head of the Department of Physics, Durham Colleges)	To 30.9.59
The late Professor H. W. B. Skinner, M.A., Ph.D., F.R.S. (Formerly Lyon Jones Professor of Physics in the University of Liverpool)	To January 1960
Professor D. H. Wilkinson, M.A., Ph.D., F.R.S. (Head of the Department of Experimental Physics, University of Oxford)	To 30.9.59

(i) *Physics Sub-committee* (12 June 1959 to 31st December 1960)

Professor Sir Harrie Massey, M.Sc., Ph.D., D.Sc., LL.D., F.R.S. (Quain Professor of Physics, University College, London)	Chairman from 12.6.59
Professor W. J. G. Beynon, C.B.E., Ph.D., D.Sc., F.Inst.P. (Head of the Department of Physics, University of Aberystwyth)	From 1.10.60
Professor B. Bleaney, M.A., D.Phil., F.R.S.* (Dr. Lee's Professor of Experimental Philosophy in the University of Oxford)	From 1.10.60
Professor B. H. Flowers, M.A., D.Sc., F.R.S. (Head of the Department of Theoretical Physics, University of Manchester)	From 12.6.59
R. S. Pease, Esq., M.A. (Atomic Energy Research Establishment, Harwell)	From 12.6.59
J. A. Ratcliffe, Esq., C.B.E., M.A., F.R.S. (Director of the Radio Research Station, Slough)	To 30.9.60

---

* Member of the Research Council between 7.11.56 and 31.12.60.

	Period of Membership
Professor P. A. Sheppard, F.Inst.P. (Head of the Department of Meteorology, Imperial College of Science and Technology, London)	From 12.6.59
Professor S. Tolansky, Ph.D., D.Sc., F.R.A.S., F.R.S. (Head of the Department of Physics, Royal Holloway College, University of London)	From 12.6.59

(j) *Technology Sub-committee* (1st October 1958 to 31st December 1960)

Professor Sir Willis Jackson, D.Phil., D.Eng., D.Sc., D.Sc.(Tech.), M.I.E.E., M.I.Mech.E., F.Inst.P., F.I.R.E., F.R.S.* (At that time a Director of Associated Electrical Industries Ltd.)	Chairman from 1.10.58
Professor Sir John Baker, O.B.E., D.Sc., Sc.D., M.I.C.E., F.R.S. (Head of the Department of Engineering and Mechanical Sciences, University of Cambridge)	From 1.10.58
N. A. de Bruyne, Esq., M.A., Ph.D., F.Inst.P. (Formerly Managing Director, CIBA (A.R.L.) Limited)	From 1.10.58
S. C. Curran, Esq., D.Sc., F.R.S. (Principal of the Royal College of Science and Technology, Glasgow)	From 1.10.60
J. Ferguson, Esq., B.Sc., Ph.D., F.R.I.C. (Imperial Chemical Industries Ltd., London)	To 30.9.60
Professor H. Ford, Ph.D., D.Sc.(Eng.), M.I.Mech.E., M.I.C.E. (Professor of Applied Mechanics, Imperial College of Science and Technology, London)	From 1.10.58
Professor M. R. Gavin, M.B.E., M.A., D.Sc., F.Inst.P., M.I.E.E. (Head of the Department of Electronic Engineering, University College of North Wales)	From 1.10.59
C. Sykes, Esq., D.Sc., Ph.D., M.I.M.E., F.Inst.P., F.R.S. (Thomas Firth & John Brown Ltd., Sheffield)	To 30.9.60
Professor M. W. Thring, M.A., F.Inst.P., F.Inst.F., M.I.Chem.E. (Newton Drew Professor of Fuel Technology and Chemical Engineering in the University of Sheffield)	From 1.10.59
J. Topping, Esq., M.Sc., Ph.D., D.I.C., F.Inst.P. (Principal of the Brunel College of Technology, London)	From 1.10.59
B. E. A. Vigers, Esq., M.A., A.M.I.C.E., M.I.C.I. (Laporte Industries Ltd., London)	From 1.10.60
Professor F. C. Williams, C.B.E., D.Phil., D.Sc., M.I.E.E., F.R.S. (Edwards Stocks Massey Professor of Electro-Technics in the University of Manchester)	From 1.10.58
M. Zvegintzov, Esq., M.A. (National Research Development Corporation, London)	From 1.10.59

---

* Since 1st October 1961, Head of the Department of Electrical Engineering at the Imperial College of Science and Technology, London.

(iv) Human Sciences Committee and its Sub-Committees (1st October 1957 to 31st December 1960)

A. HUMAN SCIENCES COMMITTEE	*Period of Membership*
W. L. Heywood, Esq., O.B.E.*† (Secretary, National Union of Dyers, Bleachers and Textile Workers)	Chairman to 12.12.57
L. T. Wright, Esq. (General Secretary, Amalgamated Weavers' Association)	Chairman from 9.1.58
P. W. S. Andrews, Esq., B.Sc.(Econ.), M.A. (Department of Economics, University of Oxford and Official Fellow of Nuffield College, Cambridge)	To 30.9.59
H. Briggs, Esq., B.A.(Econ.), B.Comm. (Labour Adviser to the Board of Unilever Ltd.)	From 1.10.57
Professor C. F. Carter, M.A.† (Stanley Jevons Professor of Political Economy in the University of Manchester)	From 1.11.59
Professor J. Drever, M.A., F.B.Ps.S. (Head of the Department of Psychology, University of Edinburgh)	To 22.8.60
Professor G. C. Drew, M.A., F.B.Ps.S. (Head of the Department of Psychology, University College, London)	From 1.10.59
E. Fletcher, Esq., M.A., A.C.A. (Head of Industrial Relations Division, Associated Industrial Consultants Ltd. since April 1961. Formerly Head of the Production Department, T.U.C.)	From 1.10.57
Professor D. V. Glass, B.Sc.(Econ.), Ph.D. (Martin White Professor of Sociology, London School of Economics and Political Science)	From 1.10.59
Professor H. M. Gluckman, M.A., D.Phil. (Head of the Department of Social Anthropology, University of Manchester)	From 1.10.57
E. W. Hancock, Esq., O.B.E., M.I.Mech.E. (Recently Director of Special Projects, Rootes Group, and General Manager, Humber Ltd., Coventry)	From 22.11.59
H. G. Jones, Esq., M.Sc., M.A., A.Inst.P. (Deputy Head of Laboratories, U.K.A.E.A., Dounreay)	To 30.9.59
Professor A. R. Knight, M.A., F.B.Ps.S. (Anderson Professor of Psychology in the University of Aberdeen)	From 14.7.60
H. G. Nelson, Esq., M.A., M.I.C.E., M.I.Mech.E., M.T.E.E. (Managing Director, English Electric Co. Ltd.)	To 30.9.59
D. A. Oliver, Esq., C.B.E., M.Sc.(Eng.), F.Inst.P., F.I.M. (Director of the B.S.A. Group Research Centre, Birmingham)	From 1.10.59

---

* Member of The Advisory Council between 1.10.56 and 6.11.56.
† Member of the Research Council between 7.11.56 and 31.12.60.

	Period of Membership
Professor E. A. G. Robinson, C.M.G., O.B.E., M.A.*† (Professor of Economics, University of Cambridge)	To 30.9.59
Miss B. N. Seear, B.A. (Lecturer in the Department of Social Science and Administration, London School of Economics and Political Science)	To 30.9.59
C. G. Williams, Esq., D.Sc., M.I.Mech.E., F.R.Ae.S. (Director of Shell Research Ltd., London)	From 1.10.59
A. T. M. Wilson, Esq., M.D., B.Sc. (Since 1958 Adviser to Unilever Ltd. on the use of the Social Sciences. Formerly Director, Tavistock Institute of Human Relations)	To 30.9.59

B. SUB-COMMITTEES OF THE HUMAN SCIENCES COMMITTEE

(a) *Ergonomics Sub-committee* (31st July 1958 to 31st December 1960)

Professor J. Drever, M.A., F.B.Ps.S. (Head of the Department of Psychology, University of Edinburgh)	Chairman to 22.8.60
Professor G. C. Drew, M.A., F.B.Ps.S. (Head of the Department of Psychology, University College, London)	From 31.7.58 Chairman from 22.11.60
D. E. Broadbent, Esq., M.A. (Director of Applied Psychology Research Unit, Cambridge)	From 31.7.58
Dr. O. G. Edholm, M.B., B.S. (National Institute for Medical Research, London)	From 31.7.58
E. Fletcher, Esq., M.A., A.C.A. (Head of the Industrial Relations Division, Associated Industrial Consultants Ltd. since April 1961. Formerly Head of the Production Department, T.U.C.)	From 31.7.58
E. W. Hancock, Esq., O.B.E., M.I.Mech.E. (Recently Director, Special Projects, Rootes Group and General Manager, Humber Ltd., Coventry)	From 22.11.60
Dr. A. H. Jones, M.B., B.Ch. (Medical Officer, British Railways)	From 1.1.59
Professor H. Kay, M.A., Ph.D. (Head of the Department of Psychology, University of Sheffield)	From 31.7.58
Professor A. R. Knight, M.A., F.B.Ps.S. (Anderson Professor of Psychology in the University of Aberdeen)	From 22.11.60
W. M. Larke, Esq. (General Manager, Stewarts & Lloyds Ltd., Bilston)	From 31.7.58
The Rev. A. T. Welford, M.A. (Department of Experimental Psychology, University of Cambridge and Fellow of St. John's College, Cambridge)	From 31.7.58

---

* Member of the Advisory Council between 1.10.56 and 6.11.56.

† Member of the Research Council between 7.11.56 and 31.12.60.

(b) *European Productivity Agency Sub-committee* (31st July 1958 to 31st December 1960)

E. Fletcher, Esq., M.A., A.C.A. (Head of Industrial Relations Division, Associated Industrial Consultants Ltd. since April 1961. Formerly Head of the Production Department, T.U.C.)	Chairman from 31.7.58
H. Briggs, Esq., B.A.(Econ.), B.Comm. (Labour Adviser to the Board of Unilever Ltd.)	From 31.7.58
C. B. Frisby, Esq., Ph.D. (Director, National Institute of Industrial Psychology, London)	From 31.7.58
Miss B. N. Seear, B.A. (Lecturer in the Department of Social Science and Administration, London School of Economics and Political Science)	To 1.4.60

(c) *Grants Sub-committee* (24th November 1959 to 31st December 1960)

H. Briggs, Esq., B.A.(Econ.), B.Comm. (Labour Adviser to the Board of Unilever Ltd.)	Chairman from 24.11.59
Professor J. Drever, M.A., F.B.Ps.S. (Head of the Department of Psychology, University of Edinburgh)	To 22.8.60
Professor G. C. Drew, M.A., F.B.Ps.S. (Head of the Department of Psychology, University College, London)	From 24.11.59
Professor D. V. Glass, B.Sc.(Econ.), Ph.D. (Martin White Professor of Sociology, London School of Economics and Political Science)	From 24.11.59
Professor H. M. Gluckman, D.Phil., M.A. (Head of Department of Social Anthropology, University of Manchester)	From 24.11.59
Professor A. R. Knight, M.A., F.B.Ps.S. (Anderson Professor of Psychology in the University of Aberdeen)	From 22.11.60

(d) *Work Study Sub-committee* (23rd January 1958 to 31st December 1959)

H. Briggs, Esq., B.A.(Econ.), B.Comm. (Labour Adviser to the Board of Unilever Ltd.)	Chairman to 31.12.59
R. Harle, Esq. (Production Department, Trades Union Congress)	To 31.12.59
G. A. Hutcheson, Esq. (Central Work Study Department, Imperial Chemical Industries Ltd.)	To 31.12.59
Professor E. H. Phelps Brown, M.B.E., M.A. (Professor of Economics of Labour, London School of Economics and Political Science)	To 31.12.59
Professor A. Rodger, M.A. (Professor of Occupational Psychology, Birkbeck College, London)	To 31.12.59
R. Telford, Esq., B.A., F.I.E.E., M.I.Prod.E. (General Works Manager, Marconi Ltd).	To 31.12.59

3. SENIOR STAFF OF GRANTS DIVISION AT 31st DECEMBER 1960

Director of Grants and Information Divisions: W. L. Francis, C.B.E., M.A., B.Sc., Ph.D.
Deputy Director (Grants): C. Jolliffe, B.Sc.
Head of Grants Division: P. D. Greenall, M.Sc.

TRAINING AWARDS SECTION

Principal Scientific Officer: A. P. J. Edwards, B.Sc.
(Officer in charge of Section, and Secretary of the Postgraduate Training Awards Committee)
Principal Scientific Officer: E. Rudd, B.Sc.(Econ.), Ph.D.
Senior Scientific Officer: Mrs. A. Jefford, M.A.
„ „ „ Miss J. Melville, B.Sc.
Higher Executive Officer: Miss K. F. Bailey

RESEARCH GRANTS SECTION

Principal Scientific Officer: L. S. Smith, M.A.
(Officer in charge of Section and Secretary of the Research Grants Committee)
Senior Scientific Officer: A. W. Honey, M.Sc.
„ „ „ D. L. Johns, B.Sc., Ph.D.
„ „ „ I. A. Learmouth, M.Sc.
„ „ „ Miss M. O. Morris, B.Sc.
Higher Executive Officer: P. E. Lawler

HUMAN SCIENCES SECTION

Principal Scientific Officer: A. B. Cherns, M.A., F.B.Ps.S.
(Officer in charge of Section and Secretary of the Human Sciences Committee)
Experimental Officer: Miss D. Butterworth, B.A.

Appendix C

Statistics: D.S.I.R. Studentships and Fellowships

Notes

(i) COMPARABILITY OF FIGURES

In 1957 the local education authorities in England and Wales and the Ministry of Education ceased awarding studentships to graduates eligible for support by D.S.I.R., and the number of D.S.I.R. Studentships was correspondingly increased. The numbers of studentships awarded by local education authorities for postgraduate training in science and technology before 1957 are not known, and so it has not proved possible to provide figures for earlier years that are strictly comparable with those given for 1957–60; those given in Appendix C1 are for D.S.I.R. awards only and so are not entirely comparable. For this reason figures for earlier years have not been given in the other appendixes.

(ii) THE LIST OF UNIVERSITIES AND COLLEGES

Wherever in this Appendix details are given of the numbers of awards taken up at individual universities and colleges, they are listed in the following order: those universities and colleges listed in recent Commonwealth Universities Yearbooks are placed in the order adopted by the Yearbook; then follow the remaining colleges, etc., listed in alphabetical order.

(iii) "NEW" AND "CURRENT" AWARDS

A "new" studentship or fellowship is one which began in the year stated. The total number of studentships or fellowships "current" on a given date includes, in addition to new awards, those which were awarded in earlier years and have since been renewed (usually at annual intervals) for a further period.

1. NUMBERS OF D.S.I.R. STUDENTSHIPS AND FELLOWSHIPS 1949–60*

Year	Numbers of D.S.I.R. Studentships on 1st October each year											Number of D.S.I.R. Research Fellowships on 1st October each year		Total cost in year beginning 1st April £
		Awards Current in each subject												
	New Awards	Biology and Bio-chemistry	Chemical Engineering and Metallurgy	Chemistry	Electrical Engin-eering	Other Engin-eering	Geology	Human Sciences	Math-ematics	Physics	TOTAL	New	Total Current	
1949	376	62	36	308	63		28	0	46	285	828	5	16	212 000
1950	382	68	33	366	66		36	0	58	283	910	3	10	237 000
1951	384	73	27	390	71		38	0	48	276	923	9	13	251 000
1952	413	78	26	419	79		41	0	50	283	976	7	14	266 000
1953	415	97	16	427	99		32	0	38	300	1009	4	11	295 000
1954	381	97	26	428	104		36	0	60	301	1052	2	8	323 000
1955	379	107	23	399	91		42	2	86	262	1012	5	8	320 000
1956	404	108	58	372	26	42	43	5	96	256	1006	4	7	317 000
1957	801	162	105	466	48	85	91	21	144	331	1453	13	18	444 000
1958	961	225	142	599	66	124	119	29	185	393	1882	14	26	660 000
1959	1179	277	187	768	78	182	169	51	227	476	2415	39	49	904 000
1960	1293	318	203	829	97	204	182	68	298	570	2769	39	75	1 105 000

* See Note (i) on page 161.

2. D.S.I.R. AWARDS HELD IN EACH UNIVERSITY, COLLEGE, ETC. AT THE BEGINNING OF OCTOBER, 1957–60

(See Chapter 2, Section II, paragraph 18, p. 24)

University, College, etc.	Year	New Studentships		Total Number of Studentships Current	Fellowships	
		Research Studentships	Advanced Course Studentships		New	Current
Birmingham University	1957	32	24	. .	2	3
	1958	41	45	. .	1	3
	1959	56	51	175	1	1
	1960	60	47	200	3	4
Bristol University	1957	26	—	. .	1	1
	1958	31	—	. .	—	1
	1959	33	—	80	2	2
	1960	40	1	97	2	3
Cambridge University	1957	60	13	. .	3	4
	1958	86	—	. .	3	6
	1959	95	—	245	5	9
	1960	73	19	281	5	11
(Also 22 "First Year" Studentships were awarded under the trial scheme*)						
Durham University Colleges, Durham	1957	12	—	. .	0	—
	1958	12	—	. .	—	—
	1959	12	4	32	0	—
	1960	19	7	53	0	—
King's College Newcastle Durham	1957	15	—	. .	0	—
	1958	22	1	. .	—	—
	1959	29	7	78	1	1
	1960	23	8	90	1	2
(Also 13 "First Year" Studentships were awarded under the trial scheme*)						
Exeter University	1957	7	—	. .	—	—
	1958	8	—	. .	—	—
	1959	9	—	24	—	—
	1960	12	—	28	—	—
Hull University	1957	6	—	. .	—	—
	1958	3	—	. .	—	—
	1959	10	—	18	—	—
	1960	13	1	26	0	—
Leeds University	1957	27	2	. .	—	—
	1958	30	—	. .	—	—
	1959	30	3	89	0	—
	1960	37	8	102	1	1
Leicester University	1957	2	—	. .	—	—
	1958	1	—	. .	—	—
	1959	6	—	8	—	—
	1960	11	—	19	—	—

The following key applies to the whole of Section 2 (pp. 163–169)

. . = Figures not available — = No application for awards made

0 = Application received and either no award given, or award given but not taken up

* See page 37

University, College, etc.	Year	New Studentships		Total Number of Studentships Current	Fellowships	
		Research Studentships	Advanced Course Studentships		New	Current
Liverpool University	1957	28	1	..	0	—
	1958	31	5	..	1	1
	1959	36	6	90	0	—
	1960	41	4	98	—	—
Bedford College	1957	1	—	..	0	—
	1958	8	—	..	1	1
	1959	7	—	15	—	1
	1960	6	—	19	—	—
Birkbeck College	1957	6	5	..	—	—
	1958	6	5	..	—	—
	1959	5	4	18	1	1
	1960	10	7	31	1	1
Imperial College of Science and Technology	1957	44	43	..	3	3
	1958	59	51	..	—	2
	1959	65	60	227	5	5
	1960	66	58	229	1	4
King's College, London	1957	21	4	..	0	2
	1958	24	3	..	1	1
	1959	26	6	70	0	—
	1960	24	4	71	2	2
London School of Economics	1957	—	2	..	—	—
	1958	—	2	..	—	—
	1959	2	4	8	—	—
	1960	3	3	7	—	—
Queen Elizabeth College	1957	—	—	..	—	—
	1958	0	—	..	—	—
	1959	0	—	—	—	—
	1960	2	—	2	—	—
Queen Mary College	1957	21	—	..	0	—
	1958	22	5	..	0	—
	1959	24	1	57	1	1
	1960	25	1	69	1	2
Royal Holloway College	1957	5	—	..	0	—
	1958	4	1	..	—	—
	1959	3	—	7	—	—
	1960	4	2	11	0	—
School of Pharmacy	1957	5	—	..	—	—
	1958	3	—	..	—	—
	1959	1	—	3	—	—
	1960	2	—	3	—	—
University College, London	1957	35	15	..	0	1
	1958	33	16	..	1	1
	1959	40	17	109	—	1
	1960	37	29	129	1	1

University, College, etc.	Year	New Studentships		Total Number of Studentships Current	Fellowships	
		Research Studentships	Advanced Course Studentships		New	Current
Westfield College	1960	1	—	1	—	—
King's College Medical School	1959	1	—	1	—	—
	1960	—	—	1	—	—
Middlesex Hospital Medical School	1959	—	1	1	—	—
	1960	—	1	1	—	—
St. Bartholomew's Hospital Medical School	1959	—	2	2	—	—
	1960	—	2	4	—	—
St. Mary's Hospital Medical School	1957	—	—	..	—	—
	1958	1	—	..	—	—
	1959	1	—	2	—	—
	1960	—	—	1	—	—
Institute of Cancer Research	1959	—	1	1	—	—
	1960	—	—	1	—	—
London School of Hygiene and Tropical Medicine	1957	1	—	..	—	—
	1958	1	—	..	—	—
	1959	1	—	3	—	—
	1960	—	—	3	—	—
Lister Institute	1957	1	—	..	—	—
	1959	1	—	2	—	—
	1960	—	—	1	—	—
TOTALS FOR LONDON UNIVERSITY	1957	140	69	..	3	6
	1958	161	83	..	3	5
	1959	177	96	526	7	10
	1960	180	108	584	6	10

University, College, etc.	Year	New Studentships		Total Number of Studentships Current	Fellowships	
		Research Studentships	Advanced Course Studentships		New	Current
Manchester University	1957	47	3	..	—	—
	1958	45	9	..	2	2
	1959	41	17	129	1	2
	1960	39	11	139	2	3
(Also 23 "First Year" Studentships were awarded under the trial scheme*)						
Manchester College of Science and Technology	1957	15	5	..	0	—
	1958	25	—	..	—	—
	1959	34	2	61	—	—
	1960	29	1	72	0	—
University College of North Staffordshire	1957	2	—	..	—	—
	1958	4	—	..	—	—
	1959	5	—	12	—	—
	1960	5	—	14	0	—
Nottingham University	1957	16	—	..	—	—
	1958	22	1	..	—	—
	1959	26	3	62	—	—
	1960	32	3	76	—	—
Oxford University	1957	61	9	..	2	2
	1958	60	9	..	2	4
	1959	82	10	199	2	2
	1960	89	12	212	4	5
Reading University	1957	5	—	..	—	—
	1958	6	—	..	—	—
	1959	8	—	17	0	—
	1960	4	—	15	1	2
Sheffield University	1957	30	7	..	0	—
	1958	29	2	..	—	—
	1959	35	3	93	1	1
	1960	27	5	104	0	1
(Also 19 "First Year" Studentships were awarded under the trial scheme*)						
Southampton University	1957	10	4	..	—	—
	1958	17	4	..	0	—
	1959	21	6	53	—	—
	1960	17	10	60	0	—
University College of Wales, Aberystwyth	1957	12	1	..	1	1
	1958	10	—	..	—	1
	1959	12	2	31	—	—
	1960	14	—	34	—	—
University College of North Wales, Bangor	1957	10	—	..	—	—
	1958	9	—	..	—	—
	1959	17	—	32	1	1
	1960	15	—	41	0	—

---

* See page 37

University, College, etc.	Year	New Studentships		Total Number of Studentships Current	Fellowships	
		Research Studentships	Advanced Course Studentships		New	Current
University College of South Wales and Monmouthshire, Cardiff	1957	10	—	..	0	—
	1958	13	—	..	—	—
	1959	15	—	37	—	—
	1960	17	—	41	—	—
University College of Swansea	1957	15	—	..	0	—
	1958	19	—	..	—	—
	1959	20	1	51	—	—
	1960	27	—	58	0	—
Aberdeen University	1957	5	—	..	—	—
	1958	7	—	..	—	—
	1959	10	—	20	0	—
	1960	14	4	32	—	—
Edinburgh University	1957	13	1	..	—	—
	1958	16	1	..	—	—
	1959	20	3	45	1	1
	1960	17	12	61	—	2
Glasgow University	1957	17	—	..	0	—
	1958	24	—	..	—	—
	1959	31	1	76	0	—
	1960	29	1	78	—	1
Glasgow Royal College of Science and Technology	1957	10	8	..	—	—
	1958	13	3	..	0	—
	1959	14	6	38	—	—
	1960	13	2	40	—	—
St. Andrews University, St. Salvator's College	1957	5	—	..	0	—
	1958	7	—	..	0	—
	1959	6	—	22	—	—
	1960	7	—	15	—	—
St. Andrews University, Queen's College Dundee	1957	1	—	..	—	—
	1958	3	—	..	0	—
	1959	3	—	7	—	—
	1960	5	—	11	0	—
Queen's University Belfast	1958	1	—	..	—	—
	1959	1	—	2	—	1
	1960	1	—	2	—	—
Battersea College of Technology	1957	1	—	..	—	—
	1958	4	—	..	—	—
	1959	4	—	7	—	—
	1960	12	3	21	—	—
The British Museum	1959	1	—	1	—	1
	1960	—	—	1	—	—

University, College, etc.	Year	New Studentships		Total Number of Student-ships Current	Fellowships	
		Research Studentships	Advanced Course Studentships		New	Current
Chelsea College of Science and Technology	1957	1	—	..	—	—
	1958	3	2	..	—	—
	1959	4	—	9	—	—
	1960	2	2	12	—	—
College of Aeronautics, Cranfield	1957	—	2	..	—	—
	1958	—	2	..	—	—
	1959	—	3	3	—	—
	1960	—	1	1	—	—
Heriot Watt College	1958	1	—	..	—	—
	1959	1	—	1	—	—
	1960	—	—	—	—	—
Leicester College of Technology	1957	1	—	..	—	—
	1958	1	—	..	—	—
	1959	1	1	3	—	—
	1960	—	—	3	—	—
Marine Biological Laboratory, Plymouth	1958	2	—	..	—	—
	1959	—	—	2	—	—
					0	—
					—	—
National College of Food Technology	1957	—	1	..	—	—
	1960	—	2	2	—	—
National College of Rubber Technology	1958	0	—	..	—	—
	1959	0	3	3	—	—
Northampton College of Advanced Technology	1957	1	1	..	—	—
	1958	0	—	..	—	—
	1959	0	—	1	—	—
	1960	2	—	2	—	—
Northern Polytechnic	1960	—	2	2	—	—
Plymouth and Davenport Technical College	1960	1	—	1	—	—
Royal College of Art	1958	—	1	..	—	—
	1959	—	—	1	—	—
Royal Technical College, Salford	1957	0	—	..	0	—
	1958	1	—	..	—	—
	1959	2	—	3	—	—
	1960	1	—	4	—	—
Sir John Cass College	1957	2	—	..	—	—
	1958	3	—	..	—	—
	1959	2	—	6	—	—
	1960	2	—	7	—	—

University, College, etc.	Year	New Studentships		Total Number of Studentships Current	Fellowships	
		Research Studentships	Advanced Course Studentships		New	Current
Torry Research Station, D.S.I.R.	1957	—	—	. .	—	—
	1958	—	—	. .	—	—
	1959	1	—	1	—	—
	1960	—	—	1	—	—
Woolwich Polytechnic	1957	1	—	. .	—	—
	1959	1	—	2	—	—
	1960	1	—	2	—	—
Awards held Overseas	1957	—		. .	1	1
	1958	5		. .	1	2
	1959	17		20	17	18
	1960	11		26	14	30
TOTALS	1957	649	152	1 453	13	18
	1958	777	184	1 882	14	26
	1959	928	251	2 415	39	49
	1960	942	274	2 769	39	75

(Also 77 "First Year" Studentships were awarded under the trial scheme)*

---

* See page 37

3. LIST OF POSTGRADUATE COURSES ACCEPTED BY D.S.I.R. AS SUITABLE FOR THE TENURE OF THEIR ADVANCED COURSE STUDENTSHIPS UP TO DECEMBER 1960

(i) Biology and Biochemistry

University, College, etc.	Subject of course	Qualification to which course leads
Bristol University	Bacteriology and microbiology	Course certificate
Imperial College, London	Applied entomology	D.I.C.
	Microbiology	D.I.C. and/or M.Sc.
King's College, London	Zoology	B.Sc. Hons.
University College, London	Biochemistry	M.Sc.
	Microbiology	M.Sc.
Nottingham University	Mycology	M.Sc.
Oxford University	Biochemistry	Prepares candidate for D. Phil. course
	Forestry	University diploma or B.Sc.
Sheffield University	Biochemistry	M.Sc.
	Microbiology	M.Sc. or university diploma
Aberdeen University	Soil science	M.Sc.
Edinburgh University	Animal genetics	University diploma

University, College, etc.	Subject of course	Qualification to which course leads
Royal College of Science and Technology, Glasgow	Food Science	College diploma
	Microbiology	College diploma

(ii) Chemical Engineering

Birmingham University	Biological engineering	M.Sc.
	Diploma course in Chemical engineering	University diploma
	Chemical engineering	M.Sc. by examination
	Metallurgy	M.Sc. or University diploma
Cambridge University	Chemical engineering	Chem. eng. tripos.
Leeds University	Ceramics	M.Sc. or University diploma
	Chemical engineering	M.Sc. or University diploma
	Gas engineering	M.Sc. or University diploma
	General fuel science	M.Sc. or University diploma
	Metallurgy	University diploma
Imperial College, London	Chemical technology	D.I.C.
	Diploma course in chemical engineering	D.I.C.
	Industrial safety	D.I.C.
	Chemical engineering	D.I.C. after 1st year. M.Sc. after submission of thesis or dissertation
	Nuclear technology (chemical)	D.I.C.
King's College, London	Chemical engineering	College diploma
University College, London	Biochemical engineering	College diploma
	Chemical engineering	College diploma
Manchester College of Science and Technology	Chemical engineering	University diploma
	Heat transfer	University diploma
	Paper technology	University diploma
	Textile chemistry	University diploma
Sheffield University	Glass technology	University diploma
	Physical metallurgy (one year course)	M.Met. or University diploma
	Physical metallurgy (two year course)	M.Met.
Edinburgh University	Chemical engineering	M.Sc.
Royal College of Science and Technology, Glasgow	Chemical process development	R.C.S.T. postgraduate diploma
	Textile technology	R.C.S.T. postgraduate diploma
Bradford Institute of Technology	Chemical engineering	College postgraduate award and eventually A.M.I.C.E.
West Ham College of Technology	Chemical engineering	College diploma

University, College, etc.	Subject of course	Qualification to which course leads
	(iii) Chemistry	
Birmingham College of Technology	Higher polymer technology	College diploma
Cambridge University	Organic and inorganic chemistry	Certificate of postgraduate study
University of Durham, Durham Colleges	Radiochemistry	M.Sc.
University of Durham, King's College, Newcastle	Chemistry of natural products	M.Sc. or 1st year Ph.D.
	Electrochemistry and radiation chemistry	M.Sc. or 1st year Ph.D.
Leeds University	High pressure chemistry and geochemistry	M.Sc.
	Theoretical chemistry	M.Sc.
	X ray and optical crystallography	M.Sc.
Imperial College, London	Analysis of food, drugs and water	D.I.C. or M.Sc.
	Analytical chemistry	D.I.C. or M.Sc.
Manchester University	Chemistry	M.Sc.
	Polymer science	M.Sc.
Sheffield University	Chemistry	Course certificate
Royal College of Science and Technology, Glasgow	Pharmaceutical chemistry	M.Sc. Glasgow University or R.C.S.T. diploma
Bradford Institute of Technology	Chemistry of high polymers	College postgraduate award
Leicester College of Technology and Commerce	Radiochemistry	College diploma
National College of Food Technology	Food quality control	College diploma
	General food technology	College diploma
National College of Rubber Technology	Plastics	Associateship of Inst. of Rubber Technologists
	Rubber technology	Associateship of Inst. of Plastics
Sir John Cass College	Radio chemistry	College diploma
	(iv) Electrical Engineering	
Birmingham University	Information engineering	M.Sc.
	Theory of electrical machinery	M.Sc. or University diploma
Imperial College, London	Applied electron physics	D.I.C.
	Automatic control systems and allied subjects	D.I.C.
	Communications and electronics	D.I.C.
	Electric traction	D.I.C.
	Electrical machines and power systems	D.I.C.
	Photo-electronics	D.I.C. or M.Sc.
King's College, London	Electrical engineering	College certificate
University College, London	Microwave engineering	College diploma

University, College, etc.	Subject of course	Qualification to which course leads
Manchester College of Science and Technology	Advanced electronics	University diploma
	Control engineering	University diploma
	Electrical machinery	University diploma
	Electrical power system analysis	University diploma
	Power systems engineering	Diploma in technical science
Southampton University	Electronics	University diploma or M.Sc.
Edinburgh University	Electronics and radio	University diploma
Glasgow University	Microwave theory and technique	M.Sc.
Royal College of Science and Technology, Glasgow	Electrical engineering	College diploma
Battersea College of Technology	Control engineering	College diploma
Northampton College of Advanced Technology	Automatic control	College diploma

(v) Engineering

University, College, etc.	Subject of course	Qualification to which course leads
Birmingham University	Coal preparation	M.Sc.
	Highway and traffic engineering	M.Sc. or diploma in graduate studies
	Operational research	M.Sc.
	Principles of engineering production and management	M.Sc.
	Soil mechanics and foundation engineering	M.Sc. or diploma in graduate studies
	Thermodynamic and related studies	M.Sc.
Cambridge University	Control engineering	Certificate of advanced study
	Mechanical sciences	Tripos. part II
	Strength of materials and theory of structure	Certificate of advanced study
King's College, Newcastle-on-Tyne	Rock mechanics and strata control	M.Sc.
	Highway engineering and traffic studies	University diploma
	Highway engineering and traffic studies (certificate course)	University certificate
	Public health engineering	(a) University certificate (b) University diploma
	Structural design	University certificate
Leeds University	Concrete technology	University diploma
	Mineral dressing and coal preparation	University diploma
Liverpool University	Building science	Diploma in building science

University, College, etc.	Subject of course	Qualification to which course leads
Imperial College, London	Aeronautics	D.I.C. and/or M.Sc.
	Applied mechanics	D.I.C.
	Concrete structures and technology	D.I.C. or M.Sc.
	Engineering hydrology	D.I.C.
	Gas turbine technology	D.I.C.
	Heat transfer and combustion	D.I.C.
	Highway engineering	D.I.C.
	Hydro-power engineering	D.I.C.
	Mining	D.I.C.
	Nuclear power	D.I.C.
	Production engineering	D.I.C.
	Public health engineering	D.I.C.
	Soil mechanics	D.I.C.
	Structural engineering	D.I.C.
Queen Mary College	Nuclear engineering	College diploma
University College, London	Photogrammetry	College diploma
Manchester University	Nuclear engineering	Diploma for advanced studies
Manchester College of Science and Technology	Automatic control	University diploma
	Experimental stress analysis	University diploma
	Highway engineering	University diploma
	Materials engineering	University diploma
	Production engineering	University diploma
	Structural engineering	University diploma
	Textile design	Diploma in technical science
	Textile industries	(a) University diploma (b) B.Sc. (second "first" degree)
Oxford University	Engineering science	B.A.(Hons.)
Sheffield University	Applied mechanics	University diploma
	Mining	University diploma
Edinburgh University	Applied dynamics	University diploma
Royal College of Science and Technology, Glasgow	Civil engineering	College diploma
	Environmental control engineering	College diploma
	Mechanical engineering	College diploma
	Mine ventilation	College diploma
	Mining geology	College diploma
	Power engineering	College diploma
	Production engineering	College diploma
	Strata control subsidence	College diploma
	Structural engineering	College diploma
The Queen's University, Belfast	Mechanical engineering	B.Sc. mech. eng.
Cranfield College of Aeronautics	Aeronautical engineering	College diploma
Royal College of Art	Industrial design engineering	Diploma of design of Royal College of Art

University, College, etc.	Subject of course	Qualification to which course leads
	(vi) Geology	
Birmingham University	Applied geophysics	M.Sc.
Durham University, Durham Colleges	Geophysics	M.Sc.
Durham University, King's College, Newcastle	Geology	B.Sc.(Hons.)
	Pure geophysics	M.Sc.
Leeds University	Applied geophysics	University diploma
Imperial College, London	Applied geophysics	D.I.C. or M.Sc.
	Engineering geology	D.I.C. or M.Sc.
	Micropalaeontology and palaeo-ecology	D.I.C.
	Mineral exploration	D.I.C.
	Petroleum reservoir engineering	D.I.C.
University College, London	Micropalaeontology	M.Sc. or College diploma
Oxford University	Geochemistry	University diploma
Sheffield University	Geology	M.Sc.
University College of Wales, Aberystwyth	Micropalaeontology	College diploma
Edinburgh University	Geophysical surveying	University diploma
	(vii) Human Sciences	
Birmingham University	Commerce	Graduates commerce diploma
Cambridge University	Principles of industrial management	Examination—no formal certificate
Liverpool University	Applied psychology	University diploma
	Industrial sociology	University diploma
Birkbeck College, London	Occupational psychology	College diploma
London School of Economics	Business administration	Course certificate
	Personnel management	Course certificate
	Social psychology	Diploma in social psychology
Manchester College of Science and Technology	Industrial administration	University diploma
	Personnel management	University diploma
Oxford University	History and philosophy of science	Diploma in the history and philosophy of science
	Personnel management	Diploma in public and social administration
University College of Wales, Aberystwyth	Economics	B.A. or B.Sc.(Hons.)
University College of South Wales and Monmouthshire, Cardiff	Personnel management	College diploma
Glasgow University	Industrial administration	Diploma in industrial administration
	(viii) Mathematics	
Birmingham University	Mathematical physics	University diploma
	Mathematical statistics	University diploma
Cambridge University	Mathematical statistics	University diploma
	Numerical analysis and automatic computing	University diploma
	Mathematics	Tripos, Part III

University, College, etc.	Subject of course	Qualification to which course leads
King's College, Newcastle	Automatic computing	University diploma
	Statistics	M.Sc.
Hull University	Mathematics	M.Sc.
Leeds University	Electronic computing	University diploma
Birkbeck College, London	Numerical analysis	College diploma
Imperial College, London	Applied mathematics	D.I.C.
	Mathematical physics	D.I.C.
	Pure mathematics	D.I.C. or M.Sc.
	Statistics	D.I.C.
London School of Economics	Theoretical statistics	M.Sc.
Royal Holloway College	Mathematics	M.Sc.
University College, London	Statistics	University diploma
	Hydro-dynamics and elasticity	M.Sc.
	Mathematics	M.Sc. by dissertation
	Mathematics	M.Sc. by examination
	Statistics	Qualifying examination in statistics
Westfield College	Mathematics	M.A.
Manchester University	Fluid dynamics	M.Sc. or diploma for advanced studies
	Mathematical statistics	Diploma in advanced studies
	Numerical analysis	University diploma
	Statistics	University diploma
Nuffield College, Oxford	Statistics	(a) University certificate (b) University diploma
Southampton University	Numerical analysis and "pegasus" programming	M.Sc. or University diploma
	Differentiable manifolds	M.Sc.
University College, Aberystwyth	Applied mathematics	Special honours in applied mathematics
University College, Swansea	Mathematical theory of statistics and computational analysis	College diploma
Aberdeen University	Mathematics	M.Sc.
	Statistics	University diploma
Edinburgh University	Mathematical physics	M.Sc.
Glasgow University	Numerical analysis	Diploma in numerical analysis
Royal College of Science and Technology, Glasgow	Applied mathematics	College diploma
Battersea College of Technology	Elasticity and hydrodynamics	M.Sc.
Chelsea College of Science and Technology	Mathematics	M.Sc.
Northampton College of Advanced Technology, London	Computing	University of London diploma
Northern Polytechnic	Mathematics	M.Sc.

University, College, etc.	Subject of course	Qualification to which course leads
Woolwich Polytechnic	Mathematics	(a) Qualifying for registration of M.Sc. (b) M.Sc.
	(ix) Physics	
Birmingham University	Physics of solids	M.Sc.
	Radioactivity	M.Sc.
	Radiobiology	M.Sc.
	Reactor physics and technology	M.Sc.
Bristol University	Medical physics	University certificate
Cambridge University	Natural sciences	Tripos. Part II
Durham Colleges, Durham University	Atmospheric physics	M.Sc.
	Cosmic rays and nuclear physics	M.Sc.
Birkbeck College, London	Crystallography	M.Sc.
Imperial College	Meteorology	D.I.C. or M.Sc.
	Technical optics	D.I.C. or M.Sc.
Institute of Cancer Research	Biophysics	M.Sc. or Ph.D.
Middlesex Hospital	Radiation physics	M.Sc.
St. Bartholomew's Hospital	Radiation physics	M.Sc.
University College, London	Theoretical atomic and high energy physics	M.Sc.
Manchester University	Physics and allied subjects	M.Sc. or University diploma
Oxford University (Clarendon Lab.)	Physics	B.Sc.(Hons.)
University College, Bangor	Molecular physics	M.Sc. or University diploma
Edinburgh University	Biophysics	University diploma
	Combined M.A. in mathematics and natural philosophy and B.Sc. in physics	B.Sc.(Hons.)
Royal College of Science and Technology, Glasgow	Applied physics	College diploma
Battersea College of Technology	Crystallography	M.Sc. or College diploma
	Microwave physics	M.Sc. or College diploma
Chelsea College of Science and Technology	Physics	M.Sc.

4. MOVEMENT WITHIN U.K. BETWEEN UNIVERSITIES ETC. OF D.S.I.R. STUDENTS TAKING UP THEIR STUDENTSHIPS: TOTALS FOR 1957–60 INCLUSIVE

(i) Universities and colleges sending more students elsewhere than they received during the years 1957–60 inclusive

University, etc.	Emigrants	Immigrants	No. of new D.S.I.R. awards taken up
Birmingham University	40	30	189
Exeter University	10	5	36
Hull University	6	4	32
Leicester University	5	2	20
King's College, London	30	9	95
Manchester University	29	18	195
Nottingham University	20	4	96
Sheffield University	27	21	140
University College of North Staffordshire	7	6	16
University College of Wales, Aberystwyth	11	3	48
University College of North Wales, Bangor	10	7	51
University College of South Wales and Monmouthshire, Cardiff ..	10	0	55
University College of Swansea ..	10	7	81
Glasgow University	13	9	101
Royal College of Science and Technology, Glasgow	14	3	50
St. Salvator's College, St. Andrews	12	4	25
Birmingham College of Technology	13	2	0
Bradford Institute of Technology	2	0	0
Bristol College of Technology* ..	1	0	0
Gloucester Technical College ..	1	0	0
Heriot Watt College, Edinburgh..	11	0	2
Hull College of Technology ..	1	0	0
Liverpool College of Technology	1	0	0
Battersea College of Technology..	13	4	21
Brunel College of Technology ..	2	0	0
Chelsea College of Science and Technology	8	0	10
Northern Polytechnic	3	0	2
Northampton College of Advanced Technology	2	1	3
Regent Street Polytechnic ..	3	0	0
Sir John Cass College	4	0	9
West Ham College of Technology	2	0	0
Woolwich Polytechnic	5	1	3
Paisley Technical College ..	1	0	0
Rutherford Technical College ..	1	0	0
Royal Technical College, Salford	6	1	4
S.W. Essex Technical College ..	2	0	0
Wolverhampton and Staffs College of Technology	1	0	0

* Now Bristol College of Advanced Technology

(ii) Universities and colleges with no net gain or loss during the years 1957 60 inclusive

University, etc.	Emigrants	Immigrants	No. of new D.S.I.R. awards taken up
King's College, Newcastle	13	13	102
London School of Economics	1	1	5
School of Pharmacy, London	1	1	11
St. Barts. Medical School	0	0	1
Queen Elizabeth College, London	1	1	2
Queen Mary College, London	10	10	92
Leicester College of Technology	0	0	3
Plymouth and Devonport Technical College	0	0	1

(iii) Universities and colleges receiving more students than they sent elsewhere during the years 1957 60 inclusive

University, etc.	Emigrants	Immigrants	No. of new D.S.I.R. awards taken up
Bristol University	13	17	130
Cambridge University	40	85	336
Durham Colleges	4	5	55
Leeds University	12	13	124
Liverpool University	11	15	136
Bedford College, London	3	5	22
Birkbeck College, London	1	17	27
Imperial College, London	36	46	234
Institute of Archaeology, London	0	1	1
Lister Institute, London	0	2	2
London School of Hygiene and Tropical Medicine	0	3	3
Royal Holloway College, London	4	8	16
St. Mary's Hospital, London	0	2	2
University College, London	22	27	145
Westfield College, London	0	1	1
Manchester College of Science and Technology	1	20	103
Oxford University	29	67	292
Reading University	3	7	23
Southampton University	2	8	65
Aberdeen University	5	7	36
Edinburgh University (excluding Heriot Watt College)	12	16	66
Queen's College, Dundee	0	3	12

(see p. 21 paragraphs 11 and 13 of Chapter 2 Section II)

5. SOURCES OF SUPPORT OF RESEARCH STUDENTS IN SCIENCE AND ENGINEERING IN GREAT BRITAIN, 1958/59

NUMBERS AND PERCENTAGES OF RESEARCH STUDENTS IN EACH SUBJECT RECEIVING SUPPORT FROM EACH SOURCE

Source	Biology and Biochemistry		Chemistry		Chem.Eng. & Metallurgy		Electrical Engineering		Other Engineering		Geology		Human Sciences		Mathematics		Physics		Total	
	Percentage of British Students	Total number of Students	Percentage of British Students	Total number of Students	Percentage of British Students	Total number of Students	Percentage of British Students	Total number of Students	Percentage of British Students	Total number of Students	Percentage of British Students	Total number of Students	Percentage of British Students	Total number of Students	Percentage of British Students	Total number of Students	Percentage of British Students	Total number of Students	Percentage of British Students	Total number of Students
University or College ..	17	102	18	271	16	77	14	24	15	44	23	55	16	17	13	27	11	75	16	692
D.S.I.R.	34	208	39	593	23	110	29	50	33	100	41	99	16	17	69	144	54	360	39	1681
Other Research Councils ..	23	140	3	42	7	32	5	9	3	8	0·8	2	12	12	1	3	2	10	6	258
Ministry of Education or Local Education Authority	3	16	10	156	3	14	2	3	3	10	10	25	8	8	2	5	13	19	6	256
Other Government Departments	4	23	4	61	9	40	14	24	7	22	2	5	2	2	0·5	1	8	56	5	234
Industry	3	19	17	257	32	149	24	41	23	70	7	16	2	2	1	2	10	63	14	619
Charitable Trusts, Learned Societies, etc.	6	39	5	76	4	21	8	14	4	12	5	13	4	4	3	6	6	37	5	222
Self Supporting	7	40	3	52	2	12	0·6	1	10	30	12	28	38	39	10	21	3	20	6	243
Other Sources	3	17	1	18	3	15	2	3	1	3	0	0	3	3	0·5	1	3	21	2	81
Total of British Students..	100	604	100	1526	100	470	100	169	100	299	100	243	100	104	100	210	100	661	100	4286
Overseas Students ..		192		200		84		90		132		58		71		90		130		1047
Total (all Students) ..		796		1726		554		259		431		301		175		300		791		5333

6. LIST OF FELLOWS

D.S.I.R. (AND D.S.I.R./N.A.T.O.) RESEARCH FELLOWSHIPS AWARDED IN 1956–60

1956

University or College of Tenure	
Birmingham University	
Department of Biochemistry	N. W. R. Daniels
Cambridge University	
Cavendish Laboratory	P. Duncumb
King's College, London	
Department of Physics	M. E. Fisher
University College, London	
Department of Physics	F. R. Stannard

1957

Birmingham University	
Department of Botany	M. E. Davies
Department of Chemistry	J. P. G. Farr
Bristol University	
Department of Physics	P. J. Duke
Cambridge University	
University Chemical Laboratory	J. R. Ogle
Cavendish Laboratory	Miss P. J. Brown M. J. Whelan
Imperial College of Science and Technology, London	
Department of Electrical Engineering	M. Redwood
Department of Mathematics	J. W. Moffat
Department of Physics	B. W. Powell
Oxford University	
Department of Botany	Miss H. M. Hallaway
Clarendon Laboratory	J. A. Carruthers
University College of Wales, Aberystwyth	
Department of Zoology	H. H. Williams
Dublin Institute for Advanced Studies	
School of Theoretical Physics	C. B. Rayner

1958

Birmingham University	
Department of Physics	C. J. Batty
Cambridge University	
Botany School	Miss E. A. C. MacRobbie
University Chemical Laboratory	J. Biggs C. J. S. M. Simpson
Liverpool University	
Nuclear Physics Research Laboratory	G. Culligan
Bedford College, London	
Department of Zoology	A. K. Kent
King's College, London	
Department of Mechanical Engineering	R. M. E. Sullivan
University College, London	
Department of Chemistry	Miss A. M. Goodall

Manchester University	
Physical Laboratories	P. D. Forsyth F. H. Read
Oxford University	
Clarendon Laboratory	W. R. Phillips
The Queen's University, Belfast	
Department of Chemistry	B. Nicholls
British Museum	
Department of Palaeontology	L. B. Tarlo
Technische Hochschule, Zurich	
Organic Chemistry Laboratory	G. E. Hall

1959

(i) D.S.I.R. RESEARCH FELLOWSHIPS

Bristol University	
Department of Civil Engineering	A. G. Davenport
Cambridge University	
Department of Engineering	J. Dunham
Department of Physics	D. W. Barron A. N. James
Department of Zoology	C. H. F. Rowell
Edinburgh University	
Department of Zoology	Miss E. Eisner
London University	
Birkbeck College	
Department of Psychology	B. N. Lewis
Imperial College	
Department of Aeronautics	J. K. Harvey
Department of Chemical Engineering	K. G. Payne
Department of Physics	A. E. Curzon F. L. Curzon
Queen Mary College	
Department of Physics	A. R. Boot
University of Manchester	
Department of Physics	L. Kay
King's College, Newcastle	
Department of Zoology	D. W. Sutcliffe
Oxford University	
Department of Physics	S. J. St-Lorant
Sheffield University	
Department of Geology	H. J. Sullivan
University College of North Wales, Bangor	
Department of Chemistry	D. A. Rees

(ii) N.A.T.O. RESEARCH FELLOWSHIPS ADMINISTERED BY THE DEPARTMENT

Denmark	
University of Copenhagen (Department of Biochemistry)	A. Coddington
France	
University of Grenoble (Laboratoires de Mechanique des Fluides)	F. P. Ricou
Laboratoire de Botanique Paris (Later at Bonn)	Miss M. A. Hudson
Germany	
University of Munich (Institute for Systematic Botany)	C. D. K. Cook

Italy	
University of Pavia (Istituto di Zoologia)	R. J. Wood
United Kingdom	
University of Birmingham (Department of Mathematical Physics)	R. F. Peierls
University of Bristol (Department of Organic Chemistry)	B. M. Woods
University of Cambridge (Department of Chemistry)	P. R. Hammond
University of Cambridge (Department of Physics)	I. C. T. Nisbet
University of London (Department of Mathematics)	T. W. B. Kibble
University of Oxford (Department of Biochemistry)	N. F. Taylor
University of Reading (Department of Geology)	A. Lees
United States	
National Institute of Allergy and Infectious Diseases, Bethesda, Maryland	I. B. R. Bowman
University of California (Department of Biological Control)	L. R. Cole
(Department of Chemistry)	J. M. Turner
University of South California (Department of Physics)	R. B. Cairns
University of Chicago (Institute for the Study of Metals)	A. R. Allnatt
Cornell University (Department of Biochemistry)	D. Jarvis
University of Delaware (Department of Chemical Engineering) (D)	W. T. Ribbin
University of Michigan (Department of Psychology)	R. Davis
University of Pennsylvania (Department of Zoology)	D. I. Wallis
Princeton University (Department of Physics)	R. Penrose

1960

(i) D.S.I.R. RESEARCH FELLOWSHIPS

Birmingham University	
Department of Chemistry	G. R. Newns
Department of Physics	J. B. Kinson C. A. Miller
Bristol University	
Department of Zoology	J. C. Hartley
Cambridge University	
Cavendish Laboratory	J. P. Dougherty J. Silcox
Department of Metallurgy	M. F. Ashby
King's College, Newcastle	
Department of Chemistry	J. Whiston
Leeds University	
Department of Chemistry	B. Mile
King's College, London	
Department of Chemistry	R. H. McDougall
Queen Mary College, London	
Department of Electrical Engineering	P. E. Secker
University College, London	
Department of Chemistry	W. J. Kirkham
Manchester University	
Department of Physics	D. Clive R. J. Ellison

Oxford University	
Department of Biochemistry	J. O. Walker
Department of Mathematics	A. H. Neilson
Observatory	M. F. Ingham
Glasgow University	
Department of Chemistry	G. C. Cameron

(ii) N.A.T.O. RESEARCH FELLOWSHIP ADMINISTERED BY THE DEPARTMENT

Denmark	
University of Copenhagen	
Theoretical Physics Institute	B. R. Easlea
France	
University of Strasbourg	
Institute of Chemistry	D. W. Theobald
Germany	
Max Planck Institut, Gottingen	
Department of Metallurgy	N. Birks
Department of Chemistry	M. R. Hoare
Technical Hochschule, Berlin	
Department of Chemistry	E. E. Boehm
Netherlands	
Municipal University, Amsterdam	
Physiological Chemistry Laboratory	G. D. Van Rossum
South Africa	
University of Witwatersrand	
Department of Geology	G. F. Hart
Sweden	
University of Uppsala	
Biochemical Institute	G. D. Baird
Institute of Physiological Research	Mrs. M. Jarvis P. G. Jarvis
Switzerland	
University of Zurich	
Department of Chemistry	J. Smith
Department of Geology	J. Starkey
Technical Hochschule, Zurich	
Theoretical Physics Institute	D. W. Robinson
United Kingdom	
Bristol University	
Department of Organic Chemistry	D. J. Anderson
Cambridge University	
Department of Chemistry	M. J. Henchman
Department of Mathematics	J. Nuttall
Imperial College, London	
Department of Chemistry	J. M. Gardner
King's College, London	
Department of Chemistry	T. Riley
Oxford University	
Department of Chemistry	P. Walker
Reading University	
Department of Physics	D. H. Niblett
United States	
Berkeley University, California	
Department of Chemistry	R. J. Ferrier

Appendix D

Statistics and Lists of Research Grants in the Period October 1956 to September 1960

Notes

(i) The fields of science under which the grants are listed are those of the subject Sub-committees of the Research Grants Committee, the Human Sciences Committee and those for space research. (The grants for the latter are paid through D.S.I.R. on the recommendation of the British National Committee on Space Research.)

(ii) The number and value of applications considered and of grants awarded in each academic year includes supplements to existing grants.

(iii) The column headed "Value" gives the sum of the total amounts announced in the year of award (i.e. the full amounts planned to cover the total cost of the investigations over the whole period required, including subsequent years).

1. NUMBER AND VALUE OF RESEARCH GRANTS AWARDED

Year (October—September)	1956/57		1957/58		1958/59		1959/60		TOTAL	
Subject	Number of Grants	Value £	Number of Grants	Value £	Number of Grants	Value £	Number of Grants	Value £	Number of Grants	Value £
Astronomy	4	44 130	6	33 575	7	233 400	10	98 678	27	409 783
Biology	14	37 133	12	36 119	51	105 240	45	221 047	122	400 139
Chemistry	24	79 409	40	146 051	59	270 800	73	254 560	196	750 820
Geology and Geophysics	6	10 971	8	53 450	24	108 512	25	153 334	63	326 267
Low Temperature and Solid State Physics ..	19	115 444	10	24 517	26	312 047	51	188 611	106	640 619
Mathematics	2	4 090	3	2 735	1	1 700	1	1 600	7	10 125
Nuclear Physics ..	22	456 946	36	604 286	52	826 501	42	767 375	152	2 655 108
Other Physics	12	36 345	6	31 470	16	72 955	17	147 731	51	288 501
Technology	12	39 670	26	107 711	45	171 491	57	308 940	140	627 812
Human Sciences ..	—	—	16	51 250	14	133 726	7	40 250	37	225 226
Space Research	—	—	—	—	—	—	26	297 543	26	297 543
	115	£824 138	163	£1 091 164	295	£2 236 372	354	£2 479 669	927	£6 631 943

2. NUMBER AND VALUE OF APPLICATIONS CONSIDERED AND RESEARCH GRANTS AWARDED

YEAR (October—September)	APPLICATIONS CONSIDERED (New and Deferred from Previous Session)		NEW APPLICATIONS CONSIDERED		GRANTS AWARDED	
	Number	Value £	Number	Value £	Number	Value £
1956/57	151	1 448 000	149	1 422 000	115	824 000
1957/58	205	1 443 000	200	1 428 000	163	1 091 000
1958/59	401	3 506 000	389	3 453 000	295	2 237 000
1959/60	484	5 780 000	443	4 649 000	354	2 480 000

3. DISPOSAL OF APPLICATIONS FOR RESEARCH GRANTS

Year October—September	1956/57	1957/58	1958/59	1959/60
Applications received	149	200	389	443
„ deferred from previous session ..	2	5	12	41
Total considered	151	205	401	484
Applications granted	115	163	295	354
„ refused	19	22	57	74
„ withdrawn or referred elsewhere ..	12	8	8	20
„ deferred to next session	5	12	41	36
	151	205	401	484

4. PERCENTAGE OF THE TOTAL VALUE OF THE GRANTS AWARDED IN EACH GROUP OF SUBJECTS PROVIDED FOR (i) STAFF, (ii) EQUIPMENT AND (iii) MATERIALS AND SERVICES

	1956/57 (Oct.–Sept.)			1957/58 (Oct.–Sept.)			1958/59 (Oct.–Sept.)			1959/60 (Oct.–Sept.)		
	Staff	Equipment	Materials and Services	Staff	Equipment	Materials and Services	Staff	Equipment	Materials and Services	Staff	Equipment	Materials and Services
	%	%	%	%	%	%	%	%	%	%	%	%
All branches of science ..	23	64	13	32	55	13	38	46	16	35	45	20
Astronomy	54	45	1	27	72	1	48	29	23	64	13	23
Biology	76	6	18	57	36	7	43	48	9	33	60	7
Chemistry	32	61	7	34	64	2	19	78	3	29	68	3
Geology	30	6	64	47	1	52	49	38	13	26	40	34
Low Temperature and Solid State Physics	32	65	3	15	33	52	20	75	5	30	52	18
Mathematics	100	—	—	29	62	9	100	—	—	97	—	3
Nuclear Physics	14	71	15	23	66	11	31	28	41	32	34	34
Other Physics	44	44	12	46	39	15	39	49	12	43	50	7
Technology	50	29	21	33	47	10	62	27	11			
Human Sciences	—	—	—	71	28	1	79	3	18	73	3	24
Space Research	—	—	—	—	—	—	—	—	—	47	33	20

5. TOTAL VALUES OF D.S.I.R. RESEARCH GRANTS AWARDED TO EACH UNIVERSITY OR COLLEGE, OCTOBER 1956 TO SEPTEMBER 1960

University	Astronomy	Biology	Chemistry	Geology	*L.T. and S.S.	Mathematics	Nuclear Physics	Other Physics	Technology	Human Sciences	Space Research	Total
	£	£	£	£	£	£	£	£	£	£	£	£
Birmingham	—	6 725	31 060	12 630	19 652	—	176 871	8 515	69 732	3 930	26 000	355 115
Bristol	—	4 680	18 105	9 250	32 762	3 000	148 304	—	20 500	35 084	—	271 685
Cambridge	65 285	44 035	37 273	59 584	171 165	1 600	42 854	43 505	24 377	12 584	15 602	517 864
Durham	—	6 494	40 989	75 265	6 762	—	21 968	2 540	5 000	—	—	159 018
Exeter	—	—	11 540	—	—	—	—	—	—	—	—	11 540
Hull	—	3 960	6 000	—	2 951	—	—	—	—	—	—	12 911
Leeds	—	13 882	41 710	—	7 000	—	63 266	—	22 444	—	—	148 302
Leicester	—	12 639	3 025	780	1 672	—	—	—	—	3 961	13 006	35 083
Liverpool	—	6 550	43 107	11 710	—	—	591 325	43 970	—	15 578	—	712 240
LONDON												
Bedford College	—	3 010	2 025	623	2 325	—	—	—	—	—	—	7 983
Birkbeck College	—	—	20 785	—	30 779	—	3 610	4 672	—	665	—	60 511
Imperial College	68 325	10 094	36 324	84,691	62 299	4 090	886 528	51 983	181 701	—	46 280	1 432 315
King's College	—	—	15 725	3 070	8 040	—	300	2 000	—	—	—	29 135
London School of Economics	—	—	—	—	—	—	—	—	—	31 474	—	31 474
Queen Mary College ..	—	13 961	10 250	—	20 665	—	9 300	—	10 100	—	—	64 276
Royal Holloway College ..	—	—	10 080	—	3 958	—	—	16 136	—	—	—	30 174
University College	6 950	13 586	44 015	4 670	1 640	—	142 035	7 486	10 540	7 190	107 535	345 647
Institute of Archæology ..	—	—	—	245	—	—	—	—	—	—	—	245
Institute of Dental Surgery ..	—	—	—	—	—	—	—	—	250	—	—	250
Lister Institute	—	17 253	5 460	—	—	—	—	—	—	—	—	22 713
Middlesex Hospital Medical School	—	23 380	—	—	—	—	—	—	—	—	—	23 380
Postgraduate Medical School	—	—	1 960	—	—	—	—	—	—	—	—	1 960
St. Bartholomew's Hospital Medical School	—	60 000	—	—	—	—	—	—	—	—	—	60 000
School of Pharmacy	—	—	1 625	—	—	—	—	—	1 470	—	—	3 095
Manchester†	225 448	8 130	60 348	—	7 404	625	332 617	41 260	83 640	29 900	32 797	822 169
University College of North Staffordshire	—	—	13 960	—	8 925	—	—	3 464	—	—	—	26 349
Nottingham	—	620	7 197	—	10 000	—	7 850	—	20 827	—	—	46 494
Oxford	3 275	49 653	94 400	49 700	119 085	—	103 785	19 578	4 490	4 900	4 560	453 426
Reading	—	4 047	2 852	—	31 700	—	—	9 040	—	8 950	5 050	61 639
Sheffield	—	—	20 003	3 794	36 100	—	—	13 090	68 325	22 548	14 728	178 488
Southampton	—	3 373	21 265	—	3 500	300	4 022	9 600	20 904	—	—	62 964

WALES												
Aberystwyth	—	3 336	8 054	—	5 355	510	—	3 000	—	—	16 530	36 785
Bangor	—	20 874	15 480	—	5 000	—	—	—	10 257	—	—	51 611
Cardiff	—	500	5 490	—	12 595	—	—	280	700	1 165	—	20 730
Swansea	—	3 975	1 042	—	—	—	—	1 000	6 410	—	—	12 427
SCOTLAND												
Aberdeen	—	22 317	3 075	—	25 100	—	—	—	5 300	—	—	55 792
Edinburgh	750	30 430	8 489	5 806	—	—	6 235	—	—	8 735	—	60 445
Glasgow	—	2 000	26 875	—	—	—	111 168	—	3 225	342	—	143 610
Royal College of Science and Technology	—	800	1 410	—	1 900	—	—	2 300	—	—	—	6 410
St. Andrews	9 150	—	12 600	—	—	—	600	1 500	—	—	—	23 850
ULSTER												
Belfast	—	—	16 185	—	—	—	—	—	10 705	—	15 455	42 345
Total for Universities ..	379 183	390 304	699 783	321 818	638 334	10 125	2 652 638	284 919	580 897	186 906	297 543	6 442 450
OTHER INSTITUTIONS												
Battersea College of Technology	—	—	3 370	—	955	—	—	—	1 100	—	—	5 425
Belfast College of Technology	—	—	—	—	—	—	—	—	385	—	—	385
Birmingham College of Advanced Technology ..	—	675	1 510	—	—	—	—	—	3 100	—	—	5 285
Borough Polytechnic ..	—	—	—	—	—	—	—	—	2 185	—	—	2 185
Bradford Institute of Technology	—	—	—	—	830	—	—	—	—	—	—	830
Brighton College of Technology	—	—	—	—	—	—	—	1 082	—	—	—	1 082
Brunel College of Technology	—	—	3 750	—	—	—	—	—	—	4 875	—	8 625
Chelsea College of Science and Technology	—	2 050	—	—	—	—	—	—	—	—	—	2 050
Derby and District Technical College	—	—	3 000	—	—	—	—	—	—	—	—	3 000
Dundee College of Technology	—	—	—	—	—	—	—	—	600	—	—	600
City of Gloucester Technical College	—	—	600	—	—	—	—	—	—	—	—	600
Leicester Technical College..	—	—	2 285	—	—	—	—	—	—	—	—	2 285
Liverpool College of Technology	—	—	5 539	4 049	—	—	—	—	—	—	—	9 588
The Polytechnic, Regent St., London	—	—	—	—	500	—	—	—	—	80	—	580
Monmouth Technical College	—	—	—	—	—	—	—	2 500	—	—	—	2 500
Newport and Monmouth College of Technology ..	—	—	—	—	—	—	—	—	100	—	—	100

*Low Temperature and Solid State Physics.

†Includes the Manchester College of Science and Technology.

University	Astronomy	Biology	Chemistry	Geology	*L.T. and S.S.	Mathematics	Nuclear Physics	Other Physics	Technology	Human Sciences	Space Research	Total
	£	£	£	£	£	£	£	£	£	£	£	£
Northampton College, London ..	—	—	350	—	—	—	—	—	—	—	—	350
Norwood Technical College..	—	—	—	—	—	—	1 820	—	—	—	—	1 820
Paddington Technical College	—	—	—	—	—	—	—	—	500	—	—	500
Plymouth Technical College	—	—	1 000	—	—	—	—	—	—	—	—	1 000
Portsmouth College of Technology	—	—	—	—	—	—	650	—	—	—	—	650
Rotherham College of Advanced Technology	—	—	—	—	—	—	—	—	3 115	—	—	3 115
Salford Royal Technical College	—	—	640	—	—	—	—	—	13 185	—	—	13 825
Sir John Cass College ..	—	—	19 103	—	—	—	—	—	—	—	—	19 103
South West Essex Technical College	—	7 110	—	—	—	—	—	—	—	—	—	7 110
Taunton Technical College ..	—	—	253	—	—	—	—	—	—	—	—	253
Welsh College of Advanced Technology	—	—	—	—	—	—	—	—	950	—	—	950
West Ham Technical College	—	—	600	—	—	—	—	—	—	—	—	600
Acton Society Trust ..	—	—	—	—	—	—	—	—	—	12 105	—	12 105
British School of Archaeology	—	—	—	400	—	—	—	—	—	—	—	400
College of Aeronautics, Cranfield	—	—	—	—	—	—	—	—	21 695	—	—	21 695
Private Observatory	600	—	—	—	—	—	—	—	—	—	—	600
Radcliffe Trustees	30 000	—	—	—	—	—	—	—	—	—	—	30 000
Royal Institute of Public Administration	—	—	—	—	—	—	—	—	—	4 200	—	4 200
Royal Military College of Science, Shrivenham ..	—	—	9 037	—	—	—	—	—	—	—	—	9 037
Tavistock Institute of Human Relations	—	—	—	—	—	—	—	—	—	17 060	—	17 060
Total for Other Institutions	30 600	9 835	51 037	4 449	2 285	—	2 470	3 582	46 915	38 320	—	189 493
GRAND TOTAL (Universities and Other Institutions) ..	409 783	400 139	750 820	326 267	640 619	10 125	2 655 108	288 501	627 812	225 326	297 543	6 631 943

Included in the table (in the Nuclear Physics column) are the following grants of over £100 000:

	£
Manchester University Linear Accelerator	305 000
Liverpool University Electrostatic Generator	404 410
British National Hydrogen Bubble Chamber (and associated equipment) in Imperial College ..	796 400

*Low Temperature and Solid State Physics

6. D.S.I.R. RESEARCH GRANTS AUTHORIZED BETWEEN 1st OCTOBER 1956 AND 30th SEPTEMBER 1960

(i) Natural Sciences and Technology

Investigator	Subject	Grant £	Period Covered
BIRMINGHAM UNIVERSITY			
Prof. R. Belcher ..	Apparatus for several integrated programmes	1 685	1 year from 1st October 1960
Dr. G. H. J. Bennett ..	Study of reactions in vacuum melting of alloys	6 500	1 year from 1st April 1960.
Prof. D. G. Catcheside ..	Fine structure of genes controlling enzymes in Neurospora	3 775	4 years from 1st October 1960
Prof. S. R. M. Ellis ..	Micro-analytical distillation column	500	1 year from 1st October 1959
Dr. L. H. Finlayson ..	Physiology of growth and involution of muscles in insects	1 800	3 years from 1st October 1960
Dr. A. B. Foster ..	Optical rotational investigations in the carbohydrate field	975	1$\frac{11}{12}$ years from 1st May, 1960
Mr. G. V. Jeffreys ..	Process variables of a batch-wise operated multistage solvent extraction process	540	2 years from 1st October 1958
Mr. G. V. Jeffreys ..	Simultaneous gas absorption and chemical reaction in a jet column.	900	2 years from 1st October 1960
Dr. A. S. Jones ..	Nucleotide sequence in ribo- and deoxy-ribonucleic acid.	5 500	2½ years from 1st February 1960.
Mr. L. Kay	Study of the use of stress waves for assessing defects in solids.	900	1 year from 1st January 1960.
Mr. E. D. Lacy	Hydrated alumino silicate glasses and melts.	6 859	3 years from 1st October 1959.
Prof. O. E. Lowenstein ..	Electron microscopic investigations of sensory end organs.	400	1 year from 1st October 1960
Dr. T. S. M. Maclean ..	Studies of high gain helical aerials for long distance communication and detection.	6 598	3 years from 1st May 1960.
Mr. K. A. McFadyen ..	Electrical conduction and break down in liquid di-electrics.	2 110	2 years from 1st October 1959.
Mr. L. G. Miskin ..	High vacuum fractionation.	1 500	2 years from 1st October 1959.
Prof. P. B. Moon ..	Maintenance of the 100 MeV synchroton and hydrogen liquifier.	27 500	1 year from 1st August 1957
Prof. P. B. Moon ..	Maintenance of the 100 MeV synchrotron and hydrogen liquifier.	26 000	1 year from August 1958.
Prof. P. B. Moon ..	Maintenance of the 100 MeV synchrotron and hydrogen liquifier.	33 726	1 year from 1st August 1959
Prof. P. B. Moon ..	Maintenance of the 100 MeV synchrotron and hydrogen liquifier.	29 642	1 year from 1st August 1960.
Prof. P. B. Moon ..	Nuclear physics research.	2 200	1 year from 1st August 1957.
Prof. P. B. Moon (with Prof. W. E. Burcham) ..	Rebuilding and operation of 37-inch cyclotron	33 360	5 years from 1st August 1957.
Prof. P. B. Moon ..	Polarization of protons	2 422	1 year from 1st January 1958

Investigator	Subject	Grant £	Period Covered
BIRMINGHAM UNIVERSITY —*contd.*			
Prof. P. B. Moon ..	Bubble chamber analysis	1 100	1 year from 1st January 1958.
Prof. P. B. Moon ..	"Truck team" to C.E.R.N.	870	1 year from 1st May 1958.
Prof. P. B. Moon ..	Counter experiments with the extracted proton beam	7 016	2 years from 1st January 1960.
Prof. P. B. Moon ..	Gamma-ray resonances.	5 563	2½ years from 1st January 1960.
Dr. F. W. Norris ..	Effect of gamma radiation on the lipids of wheat.	750	1 year from 1st July 1960.
Prof. R. E. Peierls ..	Proton-nucleus scattering	2 050	2 years from 1st January 1959.
Prof. R. E. Peierls ..	Senior visiting fellowship.	1 422	1 year from 1st October 1960.
Prof. R. E. Peierls ..	Senior Visiting Fellowship for research into transport problems in metals	1 622	1 year from 1st October, 1961
Dr. J. W. Railly ..	Hydraulic analogue of supersonic flow in radial diffusor.	3 130	3 years from 1st January 1960.
Prof. G. V. Raynor ..	Dislocation movement and reaction.	11 240	2 years from 1st October 1959.
Prof. S. C. Redshaw and Mr. R. F. Wills	Research on sedimentation tanks for sewage.	1 783	2 years from 1st July 1959.
Prof. S. C. Redshaw and Mr. I. S. T. Essery ..	Research on air entrainment in siphons	1 667	2 years from 1st July 1959.
Prof. S. C. Redshaw ..	Stress analysis of arch dams by use of electric analogues.	2 700	2 years from 1st October 1959.
Prof. J. C. Robb ..	Estimation of free radicals and reactions of ions with molecules	12 500	1 year from 1st June 1958.
Prof. F. W. Shotton ..	Effects of heat and stress on the remanent magnetism and susceptibility anisotropy of rocks.	2 930	3 years from 1st October 1958.
Prof. F. W. Shotton ..	Development of the modern British Fauna.	2 910	3 years from 1st October 1958.
Dr. R. W. H. Small ..	Crystal structure of some organic compounds.	300	2 years from 1st January 1960.
Mr. R. W. Snell (subsequently transferred to Dr. C. G. Wall)	Simultaneous steady flow of three immiscible fluids in porous media.	810	2 years from 1st October 1958.
Prof. M. Stacey	Nuclear magnetic resonance spectra and structural analysis of organic compounds.	5 000	1 year from 1st October 1958.
Prof. M. Stacey	Structure and synthesis of aromatic and heterocyclic organic fluorine compounds.	5 100	3 years from 1st October 1959.
Prof. S. A. Tobias ..	Non-linear vibrations of multi-degree freedom systems.	5 000	1 year from 1st October 1959.
Prof. S. A. Tobias ..	Dynamic instability of the grinding process.	1 800	1 year from 1st October 1960.
Prof. S. A. Tobias ..	(*a*) Dynamics of metal cutting. (*b*) Dynamic design of machine tools.	31 200	3 years from 1st March 1960.
Mr. J. Walker	Research into the moderation and diffusion of neutrons in sub-critical assemblies of uranium and moderators.	18 600	5 years from 1st October 1957.
Dr. G. T. Wright ..	Space-charge-limited current in solids.	2 730	2 years from 1st October 1960.

Investigator	Subject	Grant £	Period Covered
BRISTOL UNIVERSITY			
Dr. R. G. Chambers ..	Magneto-resistance, cyclotron resonance and magneto-acoustic resonance in metals.	550	1 year from 1st October 1958.
Mrs. K. W. Dunning ..	Search for homogeneous reactions of hydrogen with inorganic substances.	676	1 year from 1st October 1958.
Prof. D. H. Everett ..	Development of the statistical theory of liquids and solutions.	2 020	1$\frac{8}{12}$ years from 1st October 1957.
Prof. D. H. Everett ..	Heat capacities of solids at high temperatures.	580	1 year from 1st October 1959.
Prof. D. H. Everett ..	A general study of hysteresis phenomena, with special reference to the H_2 + Pd system and to magnetic hysteresis.	2 600	1 year from 1st October 1960.
Prof. D. H. Everett ..	Heat treatment of carbons.	740	1 year from 1st April 1960.
Prof. F. C. Frank ..	Observation of individual dislocations by means of x-rays.	3 304	1 year from 1st October 1959.
Prof. F. C. Frank ..	Crystallinity of polymers.	15 000	1 year from 1st February 1960.
Prof. J. E. Harris ..	Electron miscroscopic studies of fine structure.	1 800	3 years from 1st September 1960.
Mr. N. S. Hush	Electronic spectra of ionised hydrocarbons.	3 850	1 year from 1st October 1959.
Dr. J. A. Kitching ..	The physiological basis of behaviour in protozoa.	2 880	3 years from 1st June 1960.
Dr. A. R. Lang	X-ray diffraction investigation of crystal imperfections and lattice parameter variations.	3 568	1 year from 1st October 1960.
Dr. J. W. Mitchell ..	Dislocations in transparent crystals.	600	1 year from 1st October 1958.
Prof. J. L. M. Morrison..	Fatigue of metals subjected to triaxial stress.	7 800	3 years from 1st October 1960.
Prof. C. F. Powell ..	Experiments on cosmic radiation	5 000	1 year from 1st October 1959.
Prof. C. F. Powell ..	Investigations of the cosmic radiation.	7 335	3 years from 1st October 1959.
Prof. C. F. Powell ..	Experiments in high altitude detection and measurement of photon induced cascades.	14 900	2 years from 1st January 1960.
Prof. C. F. Powell ..	Fragmentation of heavy cosmic ray nuclei in hydrogen and carbon.	2 200	1 year from 1st January 1960.
Prof. C. F. Powell ..	Processing large stacks of photographic emulsion.	1 350	2 years from 1st January 1960.
Prof. C. F. Powell ..	Investigation of high altitude flight and recovery techniques in the Mediterranean.	6 500	3½ years from 1st May 1960.
Prof. C. F. Powell ..	Consolidated grant for investigations in cosmic rays and high-energy nuclear physics.	96 000	3 years from 1st August 1960.

[NOTE—This grant for £96 000 replaces all the grants held by Professor Powell which were current on 1st August 1960 with the exception of the grant " Investigations of the cosmic radiation " (£7335)].

Prof. M. H. L. Pryce ..	Measurement in relativistic Quantum Theory.	3 400	3 years from 1st October 1957.

Investigator	Subject	Grant £	Period Covered
BRISTOL UNIVERSITY *—contd.*			
Prof. G. H. Rawcliffe ..	Theoretical and experimental work on fundamentally novel types of dynamo-electric machinery and apparatus.	12 700	3 years from 1st October 1960.
Mr. R. C. Seymour ..	Adsorption of polar vapours.	2 525	3 years from 1st October 1958.
Dr. N. Thompson ..	Fatigue of refractory body-centred cubic metals.	2 240	2 years from 1st October 1957.
Prof. W. F. Whittard ..	Submarine geology of the continental shelf.	3 550	3 years from 1st October 1959.
Dr. W. D. Ollis	Structure and synthesis of natural products.	1 600	1 year from 1st January 1960.
Dr. F. C. Phillips ..	Felspars in the Connemara granite series/Preferred orientation in rock-forming minerals.	4 665	1 year from 1st October 1959.
Dr. F. H. Pollard ..	Development of inorganic research department.	3 384	1 year from 1st August 1960.
Prof. C. F. Powell and Prof. Sir Harrie Massey ..	Elementary particles produced artificially.	2 800	Supplementing £4000 authorized prior to Oct. 1956.
Prof. C. F. Powell ..	Construction of apparatus for processing large stacks of photographic emulsion for experiments in nuclear physics and cosmic radiation.	4 000	1 year from 1st October 1957.
Prof. C. F. Powell ..	Flights with free balloons of long duration (20–40 hours) at 100 000 ft.	4 000	1 year from 1st October 1957.
Prof. C. F. Powell ..	Disintegrations of great energy.	6 164	1 year from 1st January 1958.
Prof. C. F. Powell ..	Soft component of the cosmic radiation.	3 650	2 years from 1st August 1958.
Prof. C. F. Powell ..	Experiments on heavy mesons and hyperons by the photographic method	13 790	3 years from 1st October 1958.
Prof. C. F. Powell ..	Balloon flights of long duration.	2 500	1 year from 1st January 1959.
Prof. C. F. Powell ..	Search for low energy X-rays in the primary cosmic radiation.	2 075	1 year from 1st January 1959.
Prof. C. F. Powell ..	Experiments with balloons.	5 280	3 years from 1st March 1959.
Prof. C. F. Powell ..	Study of photon-induced cascades on the Jungfraujoch.	4 400	2 years from 1st April 1959.
Prof. C. F. Powell ..	Study of time variations in the primary cosmic radiation over England.	4 000	2 years from 1st April 1959.
Prof. C. F. Powell ..	Development of photometric method for identifying heavily charged primary cosmic ray particles.	575	1 year from 1st August 1959.
CAMBRIDGE UNIVERSITY			
Prof. Sir John Baker ..	Behaviour and design of steel structures subjected to pulsating and repeated loads.	11 500	3 years from 1st October 1958.
Dr. J. Barker	Pathways of respiratory metabolism in plants.	6 610	5½ years from 1st February 1957.

Investigator	Subject	Grant £	Period Covered
Dr. G. K. Batchelor ..	Research on applied mathematics and theoretical physics.	650	$2\frac{5}{12}$ years from 1st March 1959.
Dr. D. E. Blackwell ..	Observation of Zodiacal light from a high altitude station.	1 480	2 years from 1st August 1957.
Dr. F. P. Bowden ..	Decomposition in the solid state	13 500	5 years from 1st October 1957.
Dr. F. P. Bowden ..	High surface speeds.	8 875	3 years from 1st October 1958.
Dr. F. P. Bowden ..	Physical and chemical properties of solids at high pressure.	23 000	2½ years from 1st January 1961.
Mr. B. C. Browne ..	Gravity in surface ships.	150	1 year from 1st June 1959.
Mr. B. C. Browne ..	Gravity measurements in ships.	2 615	6 months from 1st January 1960.
Mr. B. C. Browne ..	Gravity measurements in ships.	20 126	3 years from 1st May 1960.
Sir Edward Bullard ..	Geophysical application of a mass spectrometer	1 149	1 year from 1st June 1957.
Sir Edward Bullard ..	Mass spectrometry of rocks.	12 454	3 years from 1st June 1959.
Prof. J. G. D. Clark ..	Application of protonmagnetometer to investigation of prehistoric sites.	750	2⅓ years from 1st October 1959.
Mr. W. Cochran ..	X-ray study of nucleotides and related compounds.	1 430	1¾ years from 1st January 1957.
Mr. R. M. Cook ..	Remanent magnetism of fired archaeological remains.	5 025	3 years from 1st July 1959.
Dr. V. E. Cosslett ..	The development of X-ray microscopy.	8 655	3 years from 1st January 1957.
Prof. A. H. Cottrell ..	Electron microscopical study of imperfections in crystalline solids	15 000	1 year from 1st March 1959
Dr. R. J. Eden	The nuclear many-body problem	1 340	2 years from 1st October 1957.
Dr. T. E. Faber	Properties of metals in the vacuum ultra-violet.	4 260	1 year from 1st October 1960.
Prof. O. R. Frisch ..	Analysis of bubble chamber photographs.	9 000	2 years from 1st August 1960.
Dr. S. D. Garrett ..	Morphogenesis of mycelial strands	1 040	2 years from 1st October 1957.
Prof. Sir James Gray ..	Factors which control rate and direction of movement of fish.	4 450	3 years from 1st October 1958.
Dr. J. Hamilton ..	π-meson scattering and dispersion relations.	1 850	2 years from 1st October 1959.
Mr. W. B. Harland	Palaeomagnetic investigation	1 275	2¼ years from 1st July 1958.
Dr. M. N. Hill	Investigation of the structure of the ocean floor and the bed of the shallow seas.	6 300	3 years from 1st October 1957.
Dr. P. B. Hirsch ..	Electron-optical observations of the arrangement and motion of dislocations in metal foils.	2 950	3 years from 1st January 1957.
Dr. P. B. Hirsch	Flow stress of metal crystals.	3 740	1 year from 1st June 1958.
Dr. P. B. Hirsch	Electron transmission microscopy of thin metal foils.	18 730	3 years from 1st October 1959.
Dr. P. B. Hirsch	Investigation of performance of high voltage electron microscopes.	585	1 year from 1st February 1961.

Investigator	Subject	Grant £	Period Covered
CAMBRIDGE UNIVERSITY —*contd.*			
Prof. Sir William Hodge	Theory of functions of several complex variables.	1 600	6 months from 1st January 1961.
Dr. P. Johnson	Investigation of macromolecules in solution.	2 740	1 year from 1st October 1959.
Dr. R. D. Keynes	Determination of temperature changes in the electric organ of the electric eel.	1 000	2 years from 1st January 1959.
Prof. H. C. Longuet-Higgins	Electron resonance studies of free radicals and other paramagnetic species.	17 230	2 years from 1st June 1959.
Dr. G. D. S. MacLellan	Re-attachment flows and cavitation in the neighbourhood of valve control ports.	200	2 years from 1st January 1959.
Dr. A. G. Maddock	Reactions with ion beams.	2 114	2 years from 1st January 1960.
Dr. F. G. Mann and Dr. W. H. Taylor	X-ray crystallographic investigation.	1 450	2 years from 1st July 1958.
Prof. Sir Nevill Mott	Maintenance of 2 MeV Van de Graaff machine.	8 500	1 year from 1st August 1957.
Prof. Sir Nevill Mott	Maintenance of 2 MeV Van de Graaff machine.	7 825	1 year from 1st August 1958.
Prof. Sir Nevill Mott	Maintenance of 2 MeV Van de Graaff machine.	2 775	1 year from 1st August 1959.
Prof. Sir Nevill Mott	Maintenance of 2 MeV Van de Graaff machine.	2 100	1 year from 1st August 1960.
Prof. Sir Nevill Mott	Theoretical investigation of magnetism.	1 200	1 year from 1st January 1961.
Prof. R. G. W. Norrish	The application of flash spectroscopy to two important aspects of chemical kinetics.	6 000	4½ years from 1st July 1957.
Dr. J. Nutting	Blue brittleness in low carbon and low alloy steels.	1 212	1 year from 1st October 1957.
Dr. R. H. Ottewill	Physico-chemical aspects of mineral flotation and allied processes.	4 207	3 years from 1st October 1960.
Prof. C. F. A. Pantin	Ultrastructure in functional analysis.	2 788	3 years from 1st October 1960.
Prof. C. F. A. Pantin	Fine structure of invertebrate animals.	12 750	1 year from 1st February 1960.
Prof. A. B. Pippard	Magnetic laboratory for study of metals.	76 060	3½ years from 1st May 1960.
Dr. R. H. Prince	Reaction mechanisms in organometallic halides of silicon and the group 4B elements.	800	1 year from 1st February 1960.
Mr. J. A. Ratcliffe	Theory of the ionosphere.	7 000	3 years from 1st October 1957.
Mr. J. A. Ratcliffe (transferred to Dr. B. H. Briggs)	Study of ionospheric and tropospheric irregularities.	4 850	3 years from 1st October 1958.
Prof. R. O. Redman	Structure and variation of solar magnetic fields.	2 080	3 years from 1st October 1958.
Prof. R. O. Redman	(*a*) Use of a Schmidt telescope for astrometry. (*b*) Spectrophotometry of the stars	6 450	1 year from 1st June 1959.
Prof. R. O. Redman	Pulse counting methods of photoelectric photometry.	4 150	3 years from 1st October 1959.
Mr. K. H. Roscoe	Sheer strength of soils	5 200	2 years from 1st April 1959.

Investigator	Subject	Grant £	Period Covered
Prof. M. Ryle	Development of new techniques and equipment for radio astronomy.	39 675	3 years from 1st October 1959.
Prof. M. Ryle	Design study for a new type of radio telescope of large resolving power.	3 450	1 year from 1st August 1960.
Prof. M. Ryle	Radio-astronomy	8 000	2 years from 1st August 1960.
Dr. B. C. Saunders ..	Studies in peroxidase action.	2 316	3 years from 1st October 1958.
Dr. A. G. Sharpe ..	Studies of the structures of inorganic flourine compounds.	470	1 year from 1st October 1959.
Dr. N. Sheppard ..	Raman spectra of molecules and ions.	4 850	1 year from 1st October 1958.
Dr. D. Shoenberg ..	Study of Fermi surface in metals.	2 850	2 years from 1st October 1957.
Dr. D. Shoenberg ..	Properties of liquid He^3.	2 400	2 years from 1st October 1958.
Dr. D. Shoenberg ..	Study of the Fermi surface in metals.	6 970	3 years from 1st February 1960.
Dr. K. F. Smith ..	Atomic beam investigation of the atomic structures and nuclear moments of the rare earths.	6 700	2 years from 1st January 1960.
Dr. D. Tabor	Study of high temperature creep using indentation hardness measurements.	1 700	2 years from 1st October 1957.
Dr. W. H. Taylor ..	Accurate measurements of X-ray scattering intensities for the determination of electron distributions in alloys and other structures.	10 540	2$\frac{7}{12}$ years from 1st August 1957.
Dr. W. H. Taylor ..	The construction of an automatic X-ray diffractometer and its appln. to the study of electron distribution in alloys and other structures.	2 920	3¼ years from 1st June 1959.
Dr. W. H. Thorpe ..	Comparative studies of the social organisation and ethology of Indian Ploceidæ (weaver birds)	7 425	5 years from 1st November 1957.
Dr. W. H. Thorpe ..	The study of vocal communication in birds.	2 800	5 years from 1st August 1957.
Dr. W. H. Thorpe ..	Bird navigation.	897	1 year from 1st October 1960.
Prof. C. E. Tilley ..	Development of X-ray microspectroscopic methods and their application to mineralogical problems.	9 740	3 years from 1st January 1959.
Dr. A. Townsend ..	Turbulent flow in lubrication films.	825	1 year from 1st October 1960.
Prof. V. B. Wigglesworth	Hormonal regulation of diurnal rhythms in insects.	1 535	3 years from 1st October 1957.
Dr. W. A. Wooster ..	The study of elastic properties of crystals by diffuse X-ray reflections.	2 875	3½ years from 1st April 1957.
DURHAM UNIVERSITY			
The Durham Colleges			
Dr. M. H. P. Bott ..	Sea-borne geophysical investigations off the N.E. coast of England.	1 500	1 year from 1st July 1959.

Investigator	Subject	Grant £	Period Covered
DURHAM UNIVERSITY—*contd.*			
The Durham Colleges—contd.			
Dr. M. H. P. Bott ..	Offshore gravity and magnetic survey, S. W. England.	3 000	2 years from 1st January 1960.
Prof. G. E. Coates ..	Synthetic inorganic chemistry with particular reference to organometallic compounds.	4 351	1 year from 1st October 1957.
Prof. G. E. Coates ..	Preparative and spectroscopic study of metal complexes.	925	1 year from 1st October 1960.
Dr. W. D. Corner ..	Magnetostriction at low temperatures.	750	1 year from 1st January 1958.
Dr. W. D. Corner ..	Measurement of magnetostricture properties of gadolinium.	412	6 months from 1st October 1958.
Prof. K. C. Dunham ..	Chemical analysis of rocks.	200	1 year from 1st June 1959.
Prof. K. C. Dunham ..	Borehole to investigate the Weardale granite.	36 050	1 year from 1st July 1960.
Prof. W. B. Fisher ..	Local climate, soil character and atmospheric pollution in County Durham.	6 000	4 years from 1st October 1959
Mr. G. F. Leedale ..	Effects of irradiation on Euglenineæ.	629	1 year from 1st January 1958.
Dr. G. R. Martin	Radiochemical studies of nuclear reactions induced by 14 MeV neutrons.	1 324	3 years from 1st October 1959
Dr. W. K. R. Musgrave	Preparation of stable fluoropolymers.	8 863	3 years from 1st October 1959.
Prof. G. D. Rochester ..	Sea level cosmic rays of great energy.	2 300	Supplementing £3250 authorised prior to October 1956.
Prof. G. D. Rochester ..	Sea level cosmic rays of great energies.	6 840	3 years from 1st October 1959.
Prof. G. D. Rochester ..	Elementary particle interactions in nuclear emulsion at 25 GeV.	3 345	2½ years from 1st April 1959.
Prof. F. V. Smith ..	Analysis of perceptual factors associated with innate responses.	4 000	3 years from 1st October 1960.
Dr. A. W. Wolfendale	Interactions of μ-mesons at $0 \cdot 5-1000$ GeV.	2 100	2 years from 1st January 1958.
Dr. A. W. Wolfendale	Precise measurements on sea level cosmic rays.	2 557	1 year from 1st January 1959.
Dr. A. W. Wolfendale	Directional measurements on cosmic ray showers.	2 175	1 year from 1st October 1960.
Dr. A. W. Wolfendale	Measurements on the rate of loss of energy for μ-mesons in the energy range $0 \cdot 5-1000$ GeV.	1 327	1 year from 1st October 1960.
Prof. D. A. Wright ..	Application of thermomagnetic effects.	4 600	2 years from 1st October 1960.
King's College, Newcastle			
Prof. J. Baddiley ..	Bacterial cell walls and nucleotides.	3 000	1 year from 1st October 1959.
Dr. F. J. Bayley ..	Heat transfer and pressure loss in fluid streams at high pressures and high velocities.	5 000	1 year from 1st August 1960.
Dr. N. N. Greenwood (transferred from Nottingham University) ..	Factors affecting the polymerization of compounds containing boron nitrogen bonds.	2 715	3 years from 1st October 1961.
Mr. R. Hide	Thermal convection in a rotating fluid.	4 475	3 years from 1st March 1959.

Investigator	Subject	Grant £	Period Covered
Dr. H. Lister	To measure the heat and mass of water and compare the processes in the hydrological cycle of a river basin and of a glacier basin.	4 750	3 years from 1st October 1960.
Dr. T. A. Littlefield	Wave-length standards in the spectrum of thorium.	2 550	3 years from 1st October 1958.
Dr. F. J. Lowes	Geomagnetic dynamos.	540	2½ years from 1st July 1958.
Dr. F. J. McQuillin	Examination of catalytic hydrogenation reactions in solution.	2 000	2 years from 1st October 1960.
Dr. S. L. Ranson	Effects of carbon dioxide on the metabolism of higher plants.	415	1 year from 1st October 1958.
Dr. P. H. Roberts	Theoretical hydrodynamics and hydromagnetics.	1 785	3 years from 1st January 1960.
Dr. D. A. Robson	The minor intrusions of Northumberland.	750	1 year from 1st July 1960.
Prof. S. K. Runcorn	Studies of rock magnetism and palaeoclimates.	12 800	3 years from 1st October 1959.
Dr. E. A. Salzen	Implanted electrode studies of the bird brain.	1 000	2 years from 1st October 1959.
Dr. E. E. Schneider	Low temperature studies of ionic crystals.	1 000	2 years from 1st October 1960.
Mr. J. Shaw	Transport of inorganic ions in aquatic animals.	450	1 year from 1st May 1960.
Prof. J. E. Weiss and Prof. W. F. K. Wynne-Jones	Radiation studies at high pressures and temperatures.	7 000	1 year from 1st October 1958.
Prof. T. S. Westoll	Investigation of palæozoic vertebrate fossils.	2 340	3 years from 1st January 1960.
Prof. W. F. K. Wynne-Jones	Mechanism of electrochemical and other heterogeneous reactions.	12 400	3 years from 1st October 1959.
EXETER UNIVERSITY			
Dr. L. H. Long	(1) Studies of covalent metal bonds. (2) Studies of combustible boron compounds.	1 990	Supplementing two earlier grants of £1575 each.
Prof. H. N. Rydon	Infra-red spectroscopy and organic chemistry.	4 800	1 year from 1st August 1958.
Prof. H. N. Rydon	Application of ultra-violet spectroscropy to research in chemistry.	2 500	2 years from 1st October 1960.
Dr. K. Schofield	The stereochemistry of piperidine and reduced quinolisine derivative.	2 250	3 years from 1st October 1957.
HULL UNIVERSITY			
Dr. G. C. Bond	Heterogeneous catalysis using isotopic tracers.	6 000	1 year from 1st October 1959.
Dr. B. T. Cromwell	Biosynthesis of alkaloids.	3 960	3 years from 1st October 1960.
Prof. G. F. J. Garlick	Study of radiation damage in compounds of elements in groups II and VI.	2 951	3 years from 1st October 1960.
LEEDS UNIVERSITY			
Dr. E. Broadhead	A study of interspecies competition for a common food supply in nature.	3 925	5 years from 1st October 1957.
Prof. D. Burton	The nature and source of the Dead Sea Scrolls made from animal skins.	2 040	2 years from 1st October 1957.

Investigator	Subject	Grant £	Period Covered
LEEDS UNIVERSITY—*contd.*			
Mr. A. W. Chronowicz	Stability and behaviour of perforated shells.	360	3 years from 1st August 1960.
Prof. E. G. Cox	Electronic computing	600	9 months from 1st January 1957.
Prof. E. G. Cox and Dr. R. S. Bradley	High pressure chemistry and geochemistry.	12 000	3 years from 1st August 1959.
Dr. D. W. J. Cruikshank and Dr. M. R. Truter.	Electronic computer programmes for crystal-structure refinement.	2 420	3 years from 1st October 1959.
Dr. S. Dagley	Biochemistry of bacteria.	382	1 year from 1st June 1959.
Prof. F. S. Dainton	Electron paramagnetic resonance studies.	10 000	1 year from 1st October 1957.
Prof. R. H. Evans	Creep in concrete.	6 100	1 year from 1st May 1958.
Dr. P. Gray	Study of reaction mechanisms, kinetics and thermochemistry of alkoxyl radicals.	3 000	3 years from 1st October 1959.
Dr. F. E. Hoare	Investigations of the electronic properties of metals and alloys.	7 000	3 years from 1st May 1960.
Prof. D. C. Johnson	Heat transfer in high-speed flow.	2 427	1 year from 1st June 1959.
Prof. D. C. Johnson and Dr. D. Dowson	Heat flow in a journal bearing.	3 382	1 year from 1st October 1960.
Prof. I. Manton	Electron microscopy of protoplasmic structures in plants.	950	6 months from 10th January 1959.
Dr. P. L. Marsden	Extension of cosmic ray neutron monitor.	1 860	2 years from 1st November 1958.
Prof. M. J. Petch (Subsequently transferred to King's College, Newcastle-upon-Tyne)	Brittle fracture of metals.	5 865	3 years from 1st October 1958.
Prof. R. D. Preston	Examination of structures involved in the transport of substances in plants.	8 125	3 years from 1st October 1960.
Prof. A. L. Robert	Minerology and hydration mechanisms in high alumina cements	1 050	2 years from 1st October 1959.
Dr. J. H. Robertson and Dr. M. R. Truter	Precision X-ray crystal analysis.	6 000	1 year from 1st January 1961.
Dr. B. F. Salvage and Mr. T. Wilson	Electrical discharges in gaseous voids in solid dielectrics with particular reference to direct voltage conditions.	2 200	2 years from 1st January 1960.
Prof. E. A. Spaul	Studies of the influence of physical and chemical agents upon the activity and metabolism of living cells.	500	1 year from 1st October 1958.
Dr. L. M. Stephenson	Design of a microwave Hall effect wattmeter.	1 150	3 years from 1st March 1961.
Prof. A. G. Ward and Dr. G. Stainsby	The structure, and properties, of aqueous gels and sols of water soluble macromolecules.	5 650	2 years from 1st October 1960.
Prof. J. G. Wilson	Prototype equipment for use in a large cosmic ray air shower experiment.	2 085	1½ years from 1st July 1958.
Prof. J. G. Wilson	Experiments on large cosmic ray showers.	52 486	3 years from 1st October 1959.

Investigator	Subject	Grant £	Period Covered
Prof. J. G. Wilson ..	Cosmic ray research.	1 835	1 year from 1st June 1959.
Prof. J. G. Wilson ..	Equipment for the construction of a large cloud chamber.	5 000	Supplementing £8500 authorised prior to October 1956.
LEICESTER UNIVERSITY			
Dr. C. Eaborn	Aromatic reactivity.	1 175	1 year from 1st October 1959.
Dr. C. Eaborn	Effects of high-energy radiation on organometallic compounds.	1 850	2 years from 1st January 1961.
Dr. D. M. Guthrie ..	Functional recovery in regenerating nerves.	350	1 year from 1st May 1960.
Mr. F. Oldfield	Quaternary history of South West France.	780	1 year from 1st July 1960.
Prof. E. A. Stewardson ..	X-ray absorption and emission spectra.	1 672	1 year from 1st October 1959.
Prof. T. G. Tutin ..	Preparation of a flora of Europe.	12 289	3 years from 1st April 1959.
LIVERPOOL UNIVERSITY			
Prof. K. F. Bowden ..	Water movements and mixing processes in the Irish Sea.	9 235	3 years from 1st January 1961.
Dr. J. Bradley	Chemical application of shock waves.	8 265	2 years from 1st February 1960.
Dr. F. D. S. Butement ..	Radio chemical research.	3 070	$1\frac{10}{12}$ years from 1st June 1958.
Prof. J. M. Cassels and Prof. A. W. Merrison ..	Reaction mechanisms for direct interaction reactions.	5 750	1 year from 1st May 1960.
Prof. J. M. Cassels and Prof. A. W. Merrison ..	Maintenance of the nuclear physics machines.	42 350	1 year from 1st August 1960.
Prof. J. M. Cassels and Prof. A. W. Merrison ..	Interaction of low energy π and μ mesons with light nuclei in a bubble chamber.	5 400	$2\frac{1}{2}$ years from 1st May 1960.
Prof. J. M. Cassels and Prof. A. W. Merrison ..	Experiments on π and μ decays.	5 000	$2\frac{1}{2}$ years from 1st May 1960.
Prof. J. D. Craggs ..	High temperature plasma	20 200	3 years from 1st October 1959.
Dr. D. Flinn	Fractionization of elements between coexisting minerals in metamorphic rocks.	2 475	3 years from 1st October 1959.
Prof. H. Frohlich ..	Theoretical investigation in nuclear and meson physics.	4 600	3 years from 1st October 1957.
Prof. G. W. Kenner ..	Synthesis of natural products and related compounds.	2 300	1 year from 1st January 1958.
Prof. J. M. Meek ..	Ionization and breakdown in gases.	23 770	3 years from 1st January 1960.
Prof. R. A. Morton ..	Research in biochemistry.	3 100	1 year from 1st October 1958.
Prof. R. A. Morton ..	Investigation on ubiquinones etc., present in tissue unsaponifiables.	1 600	1 year from 1st August 1959.
Prof. H. W. B. Skinner* ..	Maintenance of the 156 in. cyclotron and hydrogen liquefier	39 500	1 year from 1st August 1957.
Prof. H. W. B. Skinner* ..	Maintenance of cyclotron and hydrogen liquefier.	38 500	1 year from 1st August 1958.
Prof. H. W. B. Skinner* Transferred to Prof. J. M. Cassels and Prof. A. W. Merrison. ..	Maintenance of cyclotron and hydrogen liquifier.	39 650	1 year from 1st August 1959.

---

* Deceased January, 1960.

Investigator	Subject	Grant £	Period Covered
LIVERPOOL UNIVERSITY—*contd.*			
Prof. H. W. B. Skinner* Transferred to Mr. M. J. Moore	Construction of a 75 MeV Beta spectrometer.	6 040	2 years from 1st October 1958.
Prof. H. W. B. Skinner* Transferred to Prof. J. M. Cassels and Prof. A. W. Merrison	Bubble chamber studies.	1 200	3 years from 1st September 1958.
Prof. H. W. B. Skinner*	"Truck team" to C.E.R.N.	1 140	1 year from 1st April 1958.
Prof. H. W. B. Skinner* Transferred to Prof. J. M. Cassels	Construction of the tandem Van de Graaff accelerator.	402 195	3 years from 1st August 1959.
Dr. L. H. Sutcliffe	Electron spin resonance spectroscopy.	12 700	1 year from 1st October 1959.
Dr. S. Walker	Taxonomy and cytogenetics of plant genera.	1 850	3 years from 1st October 1958.
Dr. W. B. Whalley	Metabolites of marine micro-organisms.	4 367	4 years from 1st October 1958.
Dr. W. B. Whalley	Biosynthesis in micro-organisms.	13 105	5 years from 1st October 1960.
LONDON UNIVERSITY			
Bedford College			
Dr. D. M. Hall	Configurational effects in some 1234 dibenzocyclic compounds	2 025	$3\frac{2}{12}$ years from 1st October 1959.
Prof. B. C. King	Petrological and mineralogical studies of alkaline complexes in Eastern Africa.	623	1 year from 1st October 1959.
Dr. L. Pincherle	Comparison of methods for the calculation of the electronic band structure of solids.	2 325	3 years from 1st September 1959.
Dr. D. C. Spanner	Theory of sugar transport.	3 010	$3\frac{5}{12}$ years from 1st October 1958.
Birkbeck College			
Prof. J. D. Bernal	Structure and properties of substances of geomagnetic interest.	2 480	Supplementing £10 000 authorised prior to October 1956.
Prof. J. D. Bernal	Studies in the structure and properties of liquids.	17 665	3 years from 1st June 1960.
Dr. D. K. Butt	Angular correlation between coincident electrons and γ-rays.	3 610	3 years from 1st October 1960.
Dr. C. H. Carlisle	X-ray study of ribonuclease heavy metal derivatives with the object of elucidating the structure of the ribonuclease molecule	15 050	5 years from 1st October 1957.
Dr. W. Ehrenberg	Drift of carriers in zinc sulphide filaments.	922	1 year from 1st January 1960.
Dr. J. W. Jeffrey	Structure of sub-microscopic materials.	4 000	1 year from 1st June 1958.
Dr. J. W. Jeffrey	Accurate crystal structure determinations of inorganic compounds.	1 712	2 years from 1st August 1960.
Dr. J. C. E. Jennings	Absolute determination of electron momenta.	4 672	3 years from 1st January 1960.
Dr. A. L. Mackay	The crystal chemistry of the oxides and hydroxides of Fe, Co, Ni and Mn.	4 000	3 years from 1st October 1960.

---

* Deceased January, 1960.

Investigator	Subject	Grant £	Period Covered
Prof. W. G. Overend ..	Transition metal alkoxides and phosphonitrilic halides.	775	1 year from 1st January 1958.
Prof. W. G. Overend ..	Relationship between constitution and physico-chemical properties of carbohydrates.	1 955	2 years from 1st October 1959.
Dr. G. H. Williams ..	Photolytic formation and reactions of alkyl radicals in solution.	3 005	3 years from 1st October 1960.
Imperial College of Science and Technology			
Dr. D. V. Ager ..	Investigation of the internal structures of Mesozioc Brachiopoda.	2 475	5 years from 1st October 1957.
Dr. J. M. Alexander ..	Thermal creep buckling of composite members.	2 820	1¾ years from 1st June 1959.
Prof. J. H. Argyris ..	Matrix analysis of complex structures.	15 880	2¼ years from 1st June 1957.
Prof. J. H. Argyris ..	Analysis of engincering system in non-elastic regime and under large deformations.	16 775	2¾ years from 1st October 1960.
Prof. J. G. Ball	Deformation and fracture properties of molybdenum.	9 400	3 years from 1st October 1958.
Prof. R. M. Barrer ..	Chemistry, physical chemistry and X-ray crystallography of aluminosilicates and complex oxides.	1 400	1 year from 1st January 1959.
Prof. D. H. R. Barton	Sesquiterpenoid lactones.	3 276	3 years from 1st October 1957.
Prof. D. H. R. Barton	Studies in organic chemistry.	2 975	1 year from 1st October 1959.
Dr. R. L. Bell	Deformation of semiconductor crystals.	2 000	1 year from 1st October 1960.
Dr. D. M. Binnie ..	Experiments on hypernuclei.	902	1 year from 1st October 1960.
Dr. A. W. Bishop ..	Stability analysis of earth slopes.	2 150	2 years from 1st October 1958.
Mr. F. E. Bruce ..	Sedimentation tank baffles.	2 500	2 years from 1st June 1960.
Prof. J. M. Bruckshaw and Dr. R. G. Mason ..	Magnetic properties of oceanic rocks.	1 563	1 year from 1st October 1960.
Dr. A. R. Burkin ..	Pressure leacbing of minerals.	850	1 year from 1st October 1958.
Dr. A. R. Burkin ..	Behaviour of some anions containing heavy metals in alkaline solutions obtained by pressure leaching minerals.	3 180	2 years from 1st October 1959.
Prof. C. C. Butler ..	An instrument for rapid measurement of cloud and bubble chamber tracks.	2 300	1 year from 1st January 1957.
Prof. C. C. Butler ..	A cloud cbamber study of ultra high energy nuclear interactions.	11 500	2$\frac{7}{12}$ years from 1st August 1957.
Prof. C. C. Butler ..	Construction of hydrogen bubble chamber.	419 250	4 years from 1st January 1958.
Prof. C. C. Butler ..	Bubble chamber project at C.E.R.N.	117 450	1⅔ years from 1st August 1961.
Prof. C. C. Butler ..	Bubble chamber film analysis equipment.	259 700	4 years from 1st January 1958.
Prof. C. C. Butler ..	Bubble chamber experiments.	24 850	2 years from 1st January 1959.
Miss L. Chitty	An investigation of arch dams.	1 839	2¼ years from 1st October 1959.

Investigator	Subject	Grant £	Period Covered
LONDON UNIVERSITY—*contd.* *Imperial College of Science and Technology—contd.*			
Dr. J. A. Clegg	Remanent magnetism of igneous and sedimentary rocks.	5 400	3 years from 1st July 1958.
Sir Alfred Egerton (Subsequently transferred to Dr. J. H. Burgoyne). ..	Rates of combustion reactions in flowing streams of gases.	900	Supplementing £1500 authorized prior to October 1956.
Dr. S. Eilon	Variety of products in industry.	200	1 year from 1st June 1960.
Dr. H. Elliott	Time variations of the intensity of the soft component of the cosmic radiation.	3 384	2 years from 1st October 1958.
Dr. H. Elliott	Investigation of the trajectories of cosmic ray particles in the earth's magnetic field.	1 200	1 year from 1st June 1959.
Dr. H. Elliott	Senior visiting fellowship.	800	1 year from 1st October 1959.
Dr. H. Elliott	Low energy end of the primary cosmic ray proton and α-particle spectra.	6 388	2½ years from 1st July 1960.
Dr. G. Evans	Geological investigations in the South Atlantic.	2 200	3 months from 1st October 1960.
Prof. H. Ford and Dr. J. M. Alexander	Combined forming operations in metal deformations processes.	24 900	3 years from 1st December 1960.
Prof. D. Gabor ..	Thermonuclear power production	13 480	2¾ years from 1st May 1960.
Dr. P. Grootenhuis ..	H.F. vibrations and mechanical properties of metals.	3 142	3 years from 1st May 1958.
Prof. W. K. Hayman ..	Theory of integral functions.	1 040	2 years from 1st October 1957.
Prof. W. K. Hayman ..	The theory of Schlicht functions.	1 700	2 years from 1st October 1959.
Dr. L. M. Jackman ..	Nuclear magnetic resonance and its relation to steric effects in organic compounds.	2 875	3 years from 1st June 1959.
Dr. S. E. Jacobs	Nitrogen nutrition of pioneer plants.	3 654	3 years from 1st October 1959.
Prof. W. O. James ..	Relations between intracellular structure and metabolic processes in plants.	6 440	1 year from 1st February 1960.
Prof. H. Jones	Solution of differential equations.	1 350	1 year from 1st October 1958.
Dr. R. Latham	High current discharge physics.	3 285	1 year from 1st September 1958.
Dr. R. Latham	High current condenser discharges.	2 848	2 years from 1st July 1960.
Dr. R. Latham	Discharge instability and fast compression of shock heated gas.	5 595	2 years from 1st January 1960.
Prof. J. D. McGee ..	Use of commercial television pickup tube as charge-integrating signal generator.	3 365	3 years from 1st October 1958.
Prof. J. D. McGee ..	Expansion of development of single stage thin window image magnifiers.	8 340	3 years from 1st February 1959.
Prof. J. D. McGee ..	Photo-electronic devices for intensifying and/or recording optical images.	4 990	1 year from 1st October 1959.

Investigator	Subject	Grant £	Period Covered
Prof. J. D. McGee ..	Investigation of photo-electronic techniques and devices for intensifying and for recording optical images.	30 877	3 years from 1st October 1960.
Prof. J. D. McGee ..	Assessment of photo-electric image tubes.	2 525	9 months from 1st October 1960.
Dr. B. J. Mason	Structure of ice crystals.	1 530	2 years from 1st October 1957.
Dr. B. J. Mason	Radar and related studies of clouds and precipitation.	1 350	2 years from 1st January 1957.
Dr. B. J. Mason	Physics of water and ice and its application to cloud physics.	20 020	4 years from 1st October 1959.
Mr. H. I. Matthews ..	The application of high resolution electro-microscopy and electron diffraction of minute areas, to the study of fine structure, and in particular in relation to the properties of surfaces and thin films.	11 150	1 year from 1st October 1957.
Dr. P. T. Matthews ..	Elementary particle physics.	2 140	2 years from 1st September 1960.
Dr. A. P. Millman ..	Electron probe microanalysis of ore minerals.	19 215	3 years from 1st October 1960.
Dr. N. P. W. Moore ..	Flame quenching.	385	1 year from 1st May 1958.
Prof. D. M. Newitt and Dr. P. Eisenklam ..	Heat transfer to boiling liquids.	1 120	3 years from 1st October 1958.
Prof. D. M. Newitt and Dr. W. Smith	Study of interface processes.	1 400	3 years from 1st October 1958.
Prof. D. M. Newitt ..	Physico-chemical investigation at pressures up to 30 000 atms.	1 495	1 year from 1st January 1960.
Dr. L. N. Owen ..	Applications of absorption spectrophotometry to general researches in organic chemistry, with particular reference to the study of the mechanisms of fast organic reactions in solutions.	4 500	2 years from 1st October 1956.
Dr. R. W. B. Pearse ..	Measurement of intensity variations in spectra.	3 200	1½ years from 1st January 1957.
Prof. A. Porter	Application of a general purpose digital computor to study the behaviour of some proposed "logical truth" computors.	750	1 year from 1st September 1957.
Dr. P. L. Pratt	Properties of ionic and ceramic crystals, especially at high temperatures.	22 900	3½ years from 1st April 1959.
Prof. F. D. Richardson ..	Metallurgical equilibria at high temperatures and medium pressures.	22 610	5 years from 1st April 1957.
Sir Eric Rideal	Infra-red analysis of chemisorbed gases.	4 000	2 years from 1st July 1957.
Prof. A. Salam	A study of functional field theory. The theory of strange particles and their interactions.	2 075	2 years from 1st February 1958.
Prof. A. Salam	Elementary particle interactions.	1 025	1 year from 1st October 1958.
Prof. A. Salam	Nuclear theory and theory of elementary particle research.	300	1 year from 1st October 1958.
Prof. A. Salam	Elementary particle interactions.	1 772	1 year from 1st August 1959.

Investigator	Subject	Grant £	Period Covered
LONDON UNIVERSITY—*contd.*			
Imperial College of Science and Technology—contd.			
Prof. A. Salam	The theory of fundamental particles.	540	1 year from 1st October 1959.
Prof. A. Salam	Research on elementary particle interactions.	640	1 year from 1st October 1960.
Prof. A. Salam	Scattering matrix elements.	1 520	1 year from 1st October 1960.
Dr. R. Sargent	The diffusion of gases inside zeolite crystal lattices.	1 300	1 year from 1st August 1960.
Prof. P. A. Sheppard and Dr. H. Charnock ..	Turbulent transfer between wind and sea.	7 025	3 years from 1st June 1959.
Prof. D. B. Spalding ..	Study by electric analogue and other means of two and three dimensional flames.	6 400	2 years from 1st December 1957.
Prof. D. B. Spalding ..	Researches in heat transfer and combustion.	24 689	3 years from 1st October 1959.
Prof. S. R. Sparkes ..	Use of electrical analogues in the solution of structural engineering problems.	3 340	2 years from 1st January 1959.
Prof. S. R. Sparkes ..	The use of models in the design and analysis of arch dams.	6 500	2 years from 1st February 1960.
Prof. H. B. Squire ..	Hypersonic flow.	5 600	2 years from 1st October 1960.
Prof. J. Sutton	Structural geology of metamorphic rocks.	6 585	3 years from 1st September 1960.
Prof. J. Sutton and Dr. M. Kerney	An investigation of late-glacial deposits at Brook, Kent.	200	3 months from 1st July 1960.
Dr. F. C. Tompkins ..	Barrier layers in photo-conductive films.	3 330	2 years from 1st January 1959.
Prof. A. R. Ubbelohde	Research on ionic melts.	25 000	5 years from 1st October 1957.
Dr. A. J. E. Welch ..	Development of special X-ray diffraction, fluorescence and absorption techniques for use in inorganic chemistry.	5 251	1 year from 1st July 1957.
Dr. W. L. Wilcock ..	The preparation of transmission electron multiplying films, and their use for the intensification of weak radiation images.	3 024	3 years from 1st April 1957.
Prof. G. Wilkinson ..	High-resolution nuclear magnetic resonance studies.	4 000	1 year from 1st October 1958.
Prof. G. Wilkinson ..	Chemistry of transition materials.	2 955	3 years from 1st July 1959.
Prof. D. Williams and Dr. J. S. Webb	Geochemical techniques of mineral exploration.	26 900	4 years from 1st October 1958.
Prof. D. Williams and Dr. J. S. Webb	Regional geochemical reconnaissance in mineral exloration.	13 303	2¾ years from 1st January 1960.
Dr. E. P. Wohlfarth ..	Theory of the properties of ferromagnetic particles.	615	3½ months from 15th May 1960.
Dr. J. L. Wood	Vibration spectra of molecules and ions.	2 658	1 year from 1st July 1960.
Prof. W. D. Wright ..	Establishment of an optical design unit for advanced lens design	65 800	7⅓ years from 1st June 1960.
King's College			
Dr. E. J. Burge	Scattering of 30–100 MeV protons.	300	2 years from 1st October 1957.

Investigator	Subject	Grant £	Period Covered
Prof. F. C. Champion ..	Interaction of nuclear radiation in solids.	2 000	1 year from 1st October 1957.
Prof. F. C. Champion ..	Elementary particle probes for examining the structure of fundamental solids such as diamond and sulphur.	900	1 year from 1st April 1960.
Dr. F. W. Chapman ..	Propagation of audio-frequency radio waves and properties of the lower ionosphere.	2 000	3 years from 1st January 1957.
Prof. C. Domh	Statistical mechanics of the solid state.	2 540	2 years from 1st October 1960.
Mr. R. Hulme	Crystallographic investigation of inorganic complexes.	925	1 year from 1st January 1959.
Dr. W. S. Pitcher ..	Rapid methods of silicate analysis.	3 070	3 years from 1st December 1959.
Prof. W. C. Price ..	The extension of infra-red spectroscopy into the 15–100 micron range.	900	2 years from 1st January 1957.
Prof. W. C. Price ..	Application of electron spin resonance to double resonance techniques, etc.	11 900	3 years from 1st October 1959.
Prof. W. C. Price ..	Spectroscopy of the solid state.	2 000	3 years from 1st October 1959.
Prof. W. C. Price ..	Spectroscopic investigations of the liquid and solid states.	2 600	1 year from 1st March 1960.
Queen Mary College			
Dr. C. M. French ..	Influence of added organic compounds in enzyme activity.	1 300	1 year from 1st January 1960.
Dr. M. B. E. Godward	Study of the nature of the chromosomes and mitotic mechanism.	2 400	1 year from 1st October 1959.
Dr. W. J. Hickinbottom	Study of the course of the molecular rearrangement of aryl. N. nitramines and allied rearrangements.	2 520	2 years from 1st January 1961.
Prof. M. W. Humphrey-Davies	Application of automatic digital computers to the synthesis of electrical networks.	1 225	1 year from 1st October 1959.
Prof. G. O. Jones ..	Experimental studies of properties of the solidified inert gases.	5 170	2 years from 1st September 1957.
Prof. G. O. Jones ..	Spectroscopy at extreme infra-red (sub-millimetre) wave-lengths.	13 650	3 years from 1st October 1959.
Prof. G. O. Jones ..	Properties of solidified inert gases.	1 845	$2\frac{5}{12}$ years from 1st April 1960.
Dr. T. J. Lewis	Electron and ion transport processes etc.	8 000	3 years from 1st January 1960.
Dr. E. A. C. Lucken ..	Oxidation and reduction reaction of organic compounds.	550	1 year from 1st October 1959.
Prof. W. Murgatroyd ..	Studies of the behaviour of reactor lattices.	9 300	3 years from 1st October 1957.
Dr. J. G. Powles ..	High resolution nuclear magnetic resonance absorption in liquids and solids.	6 480	1 year from 1st April 1957.
Prof. J. E. Smith ..	Hypodermic impregnation in leeches.	2 039	3 years from 1st October 1957.
Prof. J. E. Smith ..	Functional morphology and evolution of arthropoda.	5 660	2 years from 1st October 1960.

Investigator	Subject	Grant £	Period Covered
LONDON UNIVERSITY— *contd.*			
Queen Mary College—contd.			
Prof. K. W. Sykes	Kinetics and mechanism of the formation of nickel carbonyl from nickel and carbon monoxide.	700	1 year from 1st June 1959.
Mr. D. A. Walker	Characterization of some carboxylating enzymes in plants.	1 200	3 years from 1st January 1959.
Dr. G. B. Walker	Dielectric loading for electron linear accelerator.	875	1 year from 1st October 1958.
Prof. C. P. Whittingham	Relationships between photosynthesis and respiration.	1 362	1 year from 1st May 1960.
Royal Holloway College			
Prof. E. J. Bourne	Mechanisms of enzymic synthesis of higher saccharides.	8 480	3 years from 1st October 1958.
Dr. D. Peters	The synthesis of non-alternant hydrocarbons and hydrocarbon ions.	1 600	2 years from 1st June 1959.
Prof. S. Tolansky	Optical studies on the behaviour of diamond machine cutting tools and their causes of failure.	1 060	1 year from 1st December 1957.
Prof. S. Tolansky	Magnetic properties of thin films.	9 981	3 years from 1st October 1958.
Prof. S. Tolansky	Construction of an improved oscillating Fabry-Perot interferometer.	1 695	1 year from 1st October 1959.
Prof. S. Tolansky	Micro-surface studies on hard materials.	1 225	1 year from 15th February 1959.
Prof. S. Tolansky	Microstructure and hardness studies on diamond (natural and synthetic) and silicon carbide.	2 733	2 years from 1st September 1960.
Prof. S. Tolansky and Prof. E. J. Bourne.	(i) Reaction studies on subhalides of boron (ii) Oscillating Fabry-Perot interferometer.	3 400	1 year from 1st July 1960.
University College			
Mr. B. B. Boycott	Olfactory brain of reptiles.	1 965	3 years from 1st May 1958.
Prof. E. H. S. Burhop	Interaction of high energy particles using nuclear emulsion technique.	2 766	2¼ years from 1st July 1959.
Prof. E. H. S. Burhop	Use of photographic emulsions in fundamental particle studies.	25 375	3 years from 1st October 1960.
Prof. M. B. Donald	Separation of nucleotides etc. from yeast.	13 425	5 years from 1st July 1958.
Dr. G. E. Fogg	Biochemical investigations on the Alga Monodus.	1 075	1 year from 1st January 1960.
Dr. J. B. Hasted	Inelastic ionic collisions.	7 486	3 years from 1st October 1960.
Prof. S. E. Hollingworth	Geochemical studies in the Glomfjord area of Northern Norway.	1 700	2 years from 1st September 1960.
Prof. Sir Christopher Ingold	Mechanism of intramolecular and gas reactions.	25 400	2 years from 1st June 1959.
Prof. Sir Christopher Ingold & Prof. R. S. Nyholm	Mechanism of inorganic chemical substitution.	2 715	3 years from 1st January 1959.
Dr. K. J. Ives	Filtration of suspensions through porous media.	1 035	1 year from 1st August 1960.
Dr. R. E. Jennings	High energy electro magnetic processes.	22 250	3 years from 1st October 1960.

Investigator	Subject	Grant £	Period Covered
Dr. K. A. Kermack and Dr. P. L. Robinson ..	Fossil land vertebrates.	370	1 year from 1st October 1956.
Dr. K. A. Kermack ..	Upper Triassic mammals from South Wales.	2 600	3 years from 1st October 1959.
Dr. J. Lewis and Dr. B. N. Figgis	Magnetic susceptibilities of co-ordination compounds at very low temperatures.	2 475	2 years from 1st October 1960.
Prof. Dame Kathleen Lonsdale	Extinction in crystal diffraction processes.	1 640	2 years from 1st October 1957.
Prof. Sir Harrie Massey ..	Scattering of electrons in the range 4–30 MeV.	3 404	3 years from 1st October 1957.
Prof. Sir Harrie Massey..	K-particles, hyperons and negative particles.	2 690	Supplementing an earlier grant of £600.
Prof. Sir Harrie Massey..	Programme with C.E.R.N. synchrocyclotron.	22 000	$3\frac{8}{12}$ years from 1st August 1957
Prof. Sir Harrie Massey..	Scattering of neutrons by deutrons.	3 000	2 years from 1st January 1958.
Prof. Sir Harrie Massey..	Construction of a large heavy liquid bubble chamber.	15 700	1 year from 1st October 1958.
Prof. Sir Harrie Massey..	Scattering of protons by protons deuterons and alpha particles.	5 240	2 years from 1st October 1958.
Prof. Sir Harrie Massey..	Interactions of K mesons and high energy protons.	3 405	Supplementing an earlier grant of £1800.
Prof. Sir Harrie Massey..	Development of a 28 MeV microtron to measure the scattering of electrons and protons.	3 824	2 years from 1st October 1959.
Prof. Sir Harrie Massey..	Measuring and data reduction concerned with bubble chamber photographs.	6 690	1 year from 1st October 1960.
Prof. Sir Harrie Massey..	Senior visiting fellowship.	2 250	1 year from 1st October 1960.
Prof. Sir Harrie Massey..	Determination of triple scattering and correlation parameters for nucleon-nucleon scattering.	3 191	3 years from 1st January 1960
Prof. Sir Harrie Massey with Dr. T. C. Griffiths ..	Polarization phenomena with nucleons and γ-rays.	20 250	3 years from 1st October 1960.
Dr. S. R. Montgomery ..	Study of unsteady flow in pipes.	6 409	3 years from 1st June 1960.
Dr. D. M. Rose ..	Neuromuscular activity and behaviour in sea anemones.	1 995	3 years from 1st January 1959.
Dr. M. J. Seaton ..	Problems in atomic physics and astrophysics.	6 950	3 years from 1st October 1960.
Dr. E. M. Shooter ..	Microhetero-geneity of proteins.	6 450	1 year from 1st May 1958.
Mr. C. Snell	Stresses in arch dams of variable thickness.	3 096	2 years from 1st October 1959.
Dr. J. P. Stevenson ..	Immunity in insects.	2 101	3 years from 1st October 1959.
Institute of Archæology			
Prof. F. E. Zeuner ..	Radiocarbon dating	245	Supplementing an earlier grant of £2000.
Lister Institute of Preventive Medicine			
Dr. R. A. Kekwick and Dr. J. M. Creeth ..	Characterization of biological macromolecules and studies of their interaction with low molecular weight substances by sedimentation analysis	8 250	1 year from 1st August 1960.

Investigator	Subject	Grant £	Period Covered
LONDON UNIVERSITY—*contd.*			
Lister Institute of Preventive Medicine—contd.			
Dr. W. J. Whelan ..	The enzymic polymerization of monosaccharides.	9 003	5 years from 1st October 1957.
Dr. W. J. Whelan ..	Modified poly-saccharides.	5 460	3 years from 1st September 1958.
Middlesex Hospital Medical School			
Prof. Sir Charles Dodds and Dr. G. L. Mills ..	Bacterial proteases.	9 000	3 years from 1st June 1958.
Dr. P. W. Sadler and Dr. D. G. O'Sullivan ..	Biological activity and special structural features in molecules.	14 380	3 years from 1st October 1957.
Postgraduate Medical School			
Dr. C. E. Dalgliesh ..	Spectrophoto-fluorimetry	820	1 year from 1st August 1958.
Dr. W. Klyne	Optical rotatory dispersion of organic compounds.	1 140	$2\frac{5}{12}$ years from 1st May 1958.
St. Bartholomew's Hospital Medical School			
Prof. J. Rotblat	Interaction of ionizing radiations with matter.	60 000	2 years from 1st September 1960.
Institute of Dental Surgery			
Mr. R. D. Bell	A series of experiments on the possibilities of lost wax casting in vacuum, using induction heating.	250	2 years from 1st July 1957.
School of Pharmacy			
Prof. W. H. Linnell ..	Infra-red spectra and structural analysis of pharmaceutical substances.	1 625	1 year from 1st January 1959.
Dr. D. Train	Fundamental studies into the mechanism of compaction of powders.	1 470	1 year from 1st January 1959.
MANCHESTER UNIVERSITY			
Dr. G. Allen	Nuclear magnetic resonance spectroscopy.	14 500	2 years from 1st October 1959.
Dr. G. R. Barker ..	Nucleotide analogues in assessment of growth status.	1 810	2 years from 1st October 1960.
Dr. J. H. Baxendale ..	Radiation chemistry of organic vapours.	2 200	1 year from 1st January 1959.
Prof. A. J. Birch ..	The chemistry of enzymic reactions.	3 200	1 year from 1st October 1959.
Prof. A. J. Birch ..	Infra-red examination of substances obtained in research examinations.	1 645	1 year from 1st January 1961.
Prof. A. J. Birch ..	Isotopically labelled precursors in the determination of the structures of antibiotics.	3 696	2 years from 1st October 1960
Prof. S. Devons	High power long pulse transmitter for radio-astronomy.	1 550	1 year from 1st January 1957
Prof. S. Devons	Construction of linear accelerator.	305 000	$4\frac{10}{12}$ years from 1st October 1957
Prof. S. Devons	Operation and maintenance of 6 MeV accelerator.	16 880	2 years from 1st August 1957
Prof. S. Devons and Dr. J. O. Newton	$\beta\gamma$ and electron pair spectra.	8 940	2 years from 1st October 1959
Prof. B. H. Flowers ..	Space-time transformations and theory of elementary particles.	975	1 year from 1st October 1958

Investigator	Subject	Grant £	Period Covered
Prof. B. H. Flowers ..	Classification of elementary particles.	822	1 year from 1st September 1959
Prof. G. Gee	Physical properties of high polymers.	13 400	3 years from 1st October 1960
Prof. W. B. Hall ..	Sub-critical uranium/water assembly.	19 500	3 years from 1st March 1960
Prof. R. Hanbury-Brown	Design study for a new type of photoelectric stellar interferometer.	5 000	2½ years from 1st October 1958
Prof. R. Hanbury-Brown	Construction and installation of a new type of photo-electric stellar interferometer.	75 000	2¼ years from 1st January 1960
Mr. L. A. Kirk	Investigation towards obtaining fundamental data on mass and heat transfer from a wetted surface in a fluidized bed.	600	2 years from 1st May 1960
Prof. Z. Kopal	Photoelectric spectroscopy of nebulæ and comets.	3 278	2 years from 1st October 1960
Prof. Sir Bernard Lovell	Study of the extragalactic radio emissions and of the aurora borealis by the radio echo technique.	9 150	1½ years from 1st October 1957
Prof. Sir Bernard Lovell	Studies of neutral hydrogen.	15 200	1 year from 1st October 1958
Prof. Sir Bernard Lovell	Research with the 250 ft. steerable Radio Telescope.	60 820	3 years from 1st October 1959
Prof. Sir Bernard Lovell	Maintenance of the 250 ft. steerable Radio Telescope.	52 000	4 years from 1st August 1958 (for an annual amount of up to £13 000)
Prof. K. Mahler ..	Research in the theory of numbers.	625	1 year from 1st October 1958
Dr. E. Mendoza and Dr. H. E. Hall	Properties of liquid He^3 at very low temperatures.	2 903	2 years from 1st January 1959
Dr. O. S. Mills	Equipment of X-ray laboratory.	3 987	1 year from 1st November 1957
Dr. O. S. Mills	Application of modern high-speed digital computer to crystallographic problems.	2 880	3 years from 1st October 1960
Dr. J. Ring	Lunar luminescence.	2 310	2 years from 1st July 1959
Dr. J. Ring *et al*	Research group in optical and spectroscopic techniques.	37 400	3 years from 1st July 1960
Dr. P. W. Rowe	Sheet pile walls in clay.	1 940	3 years from 1st October 1957
Dr. H. A. Skinner ..	Precision flame calorimetry.	3 540	3 years from 1st October 1959
Manchester College of Science and Technology			
Mr. C. R. Adamson ..	Steady state and transient simulation of power plant and networks.	5 700	3 years from 1st July 1960
Prof. A. A. Eddy ..	Chemical and enzymic aspects of the structure of living cells.	3 120	1 year from 1st October 1959
Dr. D. Fowweather ..	Room acoustics.	3 500	2 years from 1st October 1959
Prof. R. N. Haszeldine	Organic and inorganic polymers.	14 500	2 years from 1st October 1959

Investigator	Subject	Grant £	Period Covered
MANCHESTER UNIVERSITY —*contd.*			
Manchester College of Science and Technology—contd.			
Dr. F. L. Hudson ..	Effect of drying paper under side tension on its dimensional stability.	2 000	2 years from 1st June 1960
Prof. F. Koenigsberger	Machine tool project.	33 100	2 years from 1st August 1959
Prof. H. Lipson	Methods of crystal structure determination.	4 104	1 year from 1st January 1960
Prof. W. Merchant and Dr. D. M. Brotton ..	Application of digital computers to structural engineering.	2 475	3 years from 1st September 1960
Mr. G. R. Nicoll.. ..	Microwave studies for H.V.D.C. and power systems analysis.	6 100	2 years from 1st August 1960
Prof. R. H. Peters ..	Non-woven fabrics.	5 000	2 years from 1st September 1960
Mr. H. A. Turner ..	Fundamental processes in textile printing.	2 400	2 years from 1st January 1961
Prof. J. J. Vincent ..	Weft trajectories in " free pick " weft insertion.	1 325	1 year from 1st October 1959
UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE			
Dr. D. E. Davies.. ..	Formative time lags in hydrogen.	3 464	2 years from 1st October 1959
Dr. J. N. Hodgson ..	Research on the infra-red reflecting properties of liquid and solid metals.	900	1 year from 1st October 1958
Prof. D. J. E. Ingram ..	Development of rapid recording electron resonance spectrometers	8 025	3 years from 1st September 1960
Dr. S. C. Nyberg ..	Fourier-synthesis computation by N.P.L.	30	1 year from 1st April 1957
Prof. H. D. Springhall ..	Molecular structure of substances in the gas phase.	13 900	2 years from 1st October 1958
NOTTINGHAM UNIVERSITY			
Dr. L. J. Challis	Heat flow across metal/helium boundaries.	2 250	3 years from 1st January 1960
Prof. R. C. Coates ..	The stress and deflections in skew slab bridges supported on columns.	4 445	3 years from 1st February 1960
Dr. E. C. Cocking ..	Investigation of plant proteins.	620	3 years from 1st October 1960
Prof. D. D. Eley ..	Semiconductivity in organic substances.	2 148	1 year from 1st April 1960
Dr. H. Fessler	Stress distribution near cracks.	2 050	2 years from 1st October 1958
Prof. A. W. Johnson ..	Synthesis of porphyrins chlorins, corrins and related compounds.	2 675	1 year from 1st September 1959
Prof. A. W. Johnson ..	Synthesis of macrocylic pyrrolic pigments.	1 550	1 year from 1st January 1959
Prof. A. W. Johnson ..	Structural studies in terpenes.	824	1 year from 1st April 1960
Dr. J. C. Matthews ..	Properties of chromium rich iron chromium alloys.	4 000	3 years from 1st March 1960
Dr. W. F. Nash	Very high energy μ-meson interactions.	7 850	4 years from 1st October 1959
Prof. J. E. Parton ..	Network synthesis.	1 000	2 years from 1st October 1960

Investigator	Subject	Grant £	Period Covered
Prof. J. E. Parton ..	Non-destructive testing.	500	2 years from 1st October 1960
Prof. J. E. Parton ..	Transient response of nuclear reactor.	4 950	1 year from 1st September 1960
Prof. J. A. Pope (subsequently transferred to Mr. J. F. Roylance) ..	Fatigue life of notched specimens.	3 044	3 years from 1st June 1958
Prof. J. A. Pope (subsequently transferred to Mr. B. R. Dudley	Fatigue crack propagation in steel plate.	4 838	2 years from 1st October 1959
Dr. P. M. Rowell ..	Generation of microwave phonons.	1 750	3 years from 1st January 1960
Dr. J. C. Woolley ..	Optical properties of intermetallic semi conductor alloys.	2 000	1 year from 1st January 1960
OXFORD UNIVERSITY			
Dr. E. P. Abraham ..	Investigation of some natural products with biological activity.	1 000	1 year from 1st October 1959
Dr. E. P. Abraham ..	Natural products with biological activity.	1 000	1 year from 1st April 1960
Dr. R. Barer	The development and application of new methods of microscopy.	3 160	4 years from 1st May 1957
Prof. B. Bleaney	Nuclear magnetic resonance.	5 025	1 year from 1st October 1958
Prof. B. Bleaney	Investigation of materials using magnetic resonance and double resonance techniques.	35 500	$2\frac{10}{12}$ years from 1st October 1959
Prof. B. Bleaney	Preparation of single crystals for low temperature and solid state work.	3 730	2 years from 1st August 1960
Mr. A. D. Buckingham	Determination of molecular quadrupole moments.	2 450	3½ years from 1st January 1959.
Mr. J. D. Campbell ..	Study of dynamic yielding in metals.	3 825	3⅓ years from 1st January 1959
Dr. J. W. Christian and Dr. J. W. Martin ..	Electron microscopy of metals and alloys.	10 800	1 year from 1st January 1960
Dr. C. J. Danby	Application of mass spectrometry to chemical problems.	2 600	2 years from 1st October 1958
Prof. C. D. Darlington ..	The chemical effects of physical experiments with chromosomes and related problems.	11 342	5 years from 1st October 1957
Prof. C. D. Darlington ..	Electron microscopy of cell constituents.	17 560	3 years from 1st October 1958
Dr. D. T. Edmonds ..	Magnetic properties at temperatures below 1°K.	4 500	1¾ years from 1st January 1960
Dr. A. H. von Engel ..	Properties of hot plasmic gases and measurements of gas temperatures near solid surfaces.	5 800	3 years from 1st October 1960
Dr. E. B. Ford	Ecological and experimental study of Natural Selection in the butterfly Maniola Jurtina.	465	3 years from 1st January 1959
Dr. R. E. Franklin ..	Skin friction in annular flow.	665	1 year from 1st October 1959
Dr. E. T. Hall	Application of X-ray microprobe techniques to archæological problems.	10 618	2 years from 1st October 1959
Dr. E. T. Hall	Extension of X-ray fluorescence analysis to lower atomic numbers.	9 515	2½ years from 1st January 1959

Investigator	Subject	Grant £	Period Covered
OXFORD UNIVERSITY—*contd.*			
Dr. E. T. Hall and Dr. M. J. Aitken	Development of a fully transistorized proton magnetometer.	980	$1\frac{1}{2}$ years from 1st October 1958
Dr. J. Hatton	Liquid and solid helium 3 by nuclear magnetic resonance.	5 050	2 years from 1st August 1960
Dr. A. Hellawell ..	The freezing of metals and alloys.	725	1 year from 1st October 1960
Prof. Sir Cyril Hinshelwood	Application of high sensitivity electron spin resonance technique to chemical problems, especially those of reaction kinetics.	8 000	1 year from 1st October 1960
Prof. D. C. Hodgkin ..	X-ray analysis of complex compounds.	1 500	2 years from 1st October 1957
Prof. D. C. Hodgkin ..	X-ray analysis of biologically active compounds.	10 880	3 years from 1st October 1960
Prof. W. Hume-Rothery and Dr. J. W. Martin ..	Effect of dispersed phases on the properties of metals and alloys.	1 000	2 years from 1st October 1959
Prof. E. R. H. Jones ..	Organic chemistry research assisted by nuclear magnetic resonance.	14 500	1 year from 1st October 1960
Dr. P. W. Kent	Biochemical studies of amino and fluorosugars.	1 765	2 years from 1st January 1960
Dr. H. B. D. Kettlewell	Studies of melanism in moths.	3 075	3 years from 1st April 1959
Dr. N. Kurti	Nuclear orientation and nuclear cooling in magnetic fields up to 140 kilogauss.	25 060	3 years from 1st October 1959.
Dr. D. Lack	Radar research on bird migration.	760	1 year from 1st October 1958
Dr. D. Lack	Further study of bird migration by high-power radar.	4 950	3 years from 1st September 1959
Dr. L. Leyton	Hydrological relations of forest crops.	5 216	3 years from 1st June 1959
Dr. J. W. Linnett ..	Gaseous oxidation of boron hydrides.	2 650	3 years from 1st October 1958
Dr. J. W. Linnett ..	Identification and examination of unstable intermediates present in gaseous reacting systems.	13 705	2 years from 1st January 1959
Dr. K. G. Mendelssohn	He^3 cryogenics.	2 500	1 year from 1st October 1958
Prof. H. H. Plaskett (subsequently transferred to Prof. D. E. Blackwell) ..	Measurement of solar spectra.	3 275	3 years from 1st October 1958
Dr. M. W. Porter ..	Barker Index of Crystals.	300	Supplementing £300 on previous grant; extension of $2\frac{7}{12}$ years.
Dr. R. E. Richards ..	Variable frequency nuclear resonance spectroscopy.	8 970	2 years from 1st October 1960
Dr. R. E. Richards ..	Nuclear resonance spectroscopy.	7 750	1 year from 1st July 1958
Dr. H. M. Rosenberg ..	Ultrasonic experiments at microwave frequencies.	7 100	2 years from 1st August 1960
Dr. L. A. Stocken ..	Biochemical mechanisms of cell division.	1 220	1 year from 1st October 1959
Mr. N. Tinbergen ..	Comparative studies of estrilidine finches.	1 400	2 years from 1st August 1959
Prof. G. C. Varley ..	Population dynamics of winter moth etc.	1 900	2 years from 15th April 1958

Investigator	Subject	Grant £	Period Covered
Dr. L. M. Venanzi ..	Magnetic transitions in complexes of Ni(II).	1 300	1 year from 1st October 1960
Prof. L. R. Wager ..	Geological age of rock series.	45 350	4 years from 1st October 1958
Prof. L. R. Wager and Dr. G. M. Bruwn	Petrological and vulcanological investigations in the Leeward and Windward Islands.	4 050	5 years from 1st September 1960
Prof. D. H. Wilkinson ..	Maintenance of the synchroton.	4 000	1 year from 1st August 1957
Prof. D. H. Wilkinson ..	Maintenance of synchrotron.	3 100	1 year from 1st August 1958
Prof. D. H. Wilkinson ..	Maintenance of synchrotron.	2 750	1 year from 1st August 1959
Prof. D. H. Wilkinson ..	Maintenance of synchrotron.	2 800	1 year from 1st August 1960
Prof. D. H. Wilkinson ..	Computer programming for analysis of track photographs.	5 150	3 years from 1st October 1958
Prof. D. H. Wilkinson ..	Gamma rays from nuclear interactions of nucleons of high energy.	5 685	2 years from 1st August 1958
Prof. D. H. Wilkinson ..	Investigation of the heavy primary cosmic rays.	1 400	1 year from 1st July 1958
Prof. D. H. Wilkinson ..	Establishment of a nuclear-emulsion group.	35 900	3 years from 1st July 1959
Prof. D. H. Wilkinson ..	Nuclear structure experiments at medium energies.	2 800	2 years from 1st January 1959.
Prof. D. H. Wilkinson ..	Nuclear structure experiments at medium energies.	2 800	2 years from 1st January 1959
Prof. D. H. Wilkinson ..	Nuclear structure investigations at medium energies.	9 100	2 years from 1st August 1960
Prof. D. H. Wilkinson ..	Establishment of computing group.	28 850	7 years from 1st April 1960
Prof. D. H. Wilkinson ..	Scattering of polarized protons by deuterons.	2 250	2 years from 1st October 1960
Dr. J. Wilks	Quantum effects in liquid helium 3.	8 325	3 years from 1st October 1959
Prof. D. D. Woods ..	The mechanism of aromatic substitution by bacteria and other Micro-organisms.	5 650	$1\frac{8}{12}$ years from 1st January 1958
Dr. L. A. Woodward ..	Raman spectroscopy for the investigation of chemical problems.	1 000	3 years from 1st June 1959
Dr. G. T. Young.. ..	Synthesis of peptides.	9 550	5 years from 1st October 1960
Dr. G. T. Young.. ..	Structural investigation and synthesis of peptides.	1 170	1 year from February 1960
READING UNIVERSITY			
Prof. R. W. Ditchburn ..	Electron irradiation effects in crystals.	31 700	4 years from 1st July 1957
Prof. R. W. Ditchburn ..	Ultraviolet absorption spectroscopy (atomic vapours).	9 040	3 years from 1st October 1960
Prof. T. M. Harris and Dr. J. Warren Wilson ..	Regeneration of cambia.	2 472	4 years from 1st July 1960
Dr. P. F. Holt and Dr. J. E. Prue	(*a*) Polycyclic cinnolines (*b*) Interactions between ions in solution.	2 852	1 year from 1st October 1960
Prof. C. Tyler	Comparison of the shells of wild birds' eggs.	1 575	3 years from 1st October 1959
Prof. D. N. de G. Allen..	Investigation into the theoretical methods of design of arch dams.	2 285	2 years from 1st October 1960

Investigator	Subject	Grant £	Period Covered
SHEFFIELD UNIVERSITY			
Prof. N. S. Boulton and Mr. M. S. Clements	Flow patterns in sedimentation tanks.	500	3 years from 1st December 1958
Prof. A. L. Cullen	Millimetre wave probe techniques.	30 500	5 years from 1st October 1958
Prof. J. P. Duncan and Dr. J. F. Wallace	Drawing of cylindrical tubes.	2 600	2 years from 1st May 1958
Prof. J. P. Duncan and Mr. P. B. N. Neal	Fixed thrust pads.	2 540	2 years from 1st May 1958
Prof. J. P. Duncan	Performance of hydraulic piston control valves.	2 465	2 years from 1st October 1960
Mr. T. B. Ferguson	Effect of volute and vaneless diffuser geometry on centrifugal blower performance.	2 000	3 years from 1st October 1959
Prof. R. D. Haworth	Constitution of tannins.	3 290	3 years from 1st October 1958
Prof. R. D. Haworth and Prof. G. Porter	Researches in structural organic chemistry and study of free radicals and triplet states.	14 500	2 years from 1st October 1960
Dr. T. R. Kaiser	Radio investigations of the upper atmosphere.	8 850	3 years from 1st October 1959
Dr. A. S. C. Lawrence	Soap-water-amine systems with special reference to lower consolate temperatures.	620	1 year from 1st October 1957
Dr. P. Mohr	Geochemical studies of coal measures sediments.	3 794	1 year from 1st September 1960
Prof. G. Porter	Unstable intermediates in chemical reactions.	1 593	1 year from 1st January 1958
Prof. A. G. Quarrell	Transformations in steels.	36 000	3 years from 1st October 1959
Dr. R. S. Tebble	The magnetic susceptibility of the transition elements and their alloys at high temperatures.	4 240	3 years from 1st May 1958
Dr. R. S. Tebble	Application of electron microscopy to magnetic investigations.	100	3 months from 1st October 1960
Prof. M. W. Thring	Studies of the formation and combustion of coal smoke.	15 635	5 years from 1st July 1958
Prof. M. W. Thring	High steady state temperature with controlled atmosphere.	9 800	2½ years from 1st September 1960
SOUTHAMPTON UNIVERSITY			
Prof. A. N. Black	Self adjusting servomechanisms.	1 460	2 years from 1st October 1960
Mr. E. Cartmell	Raman spectroscopy using electrode-less sources excited by microwave radiation.	1 970	1 year from 1st October 1960
Dr. E. A. S. Cavell	Dielectric absorption in non-aqueous solutions of electrolytes.	1 250	1 year from 1st January 1960
Prof. R. C. Cookson	The rôle of ion-pairs and covalent intermediates in organic reactions and rearrangements.	1 540	2 years from 1st October 1957
Prof. R. C. Cookson	Investigation of the structure of shellac.	2 600	3 years from 1st October 1957
Mr. M. J. Delaney	Systematics and ecology of the insular species of British small mammals.	1 025	2 years from 1st October 1959
Dr. G. W. A. Fowles	Studies of solutions of transition metal compounds in liquid ammonia and amines.	2 380	2 years from 1st October 1960

Investigator	Subject	Grant £	Period Covered
Mr. H. M. Frey	Reactions of methylene and of ethylidene in the gas phase.	4 750	1 year from 1st June 1959
Mr. J. B. Hunt	The impedance characteristics of an oil film.	2 215	2 years from 1st September 1960
Prof. H. A. Jahn	Determination of nuclear forces from empirical data.	4 022	4 years from 1st October 1957
Prof. H. A. Jahn	Tabulation of 2 Wigner symbols.	300	2½ years from 1st July 1958
Dr. H. G. Jerrard	Molecular characteristics of macromolecular substances.	9 600	1 year from 1st May 1960
Dr. G. A. Kerkut	Analysis of the activity of nerve cells in close proximity within the central nervous system of invertebrates.	1 260	1 year from 1st October 1959
Prof. P. B. Morice	Elastic and ultimate behaviour of cladded and infilled structural frames.	3 375	3 years from 1st October 1959
Prof. P. B. Morice	Stress analysis of arch dams.	1 050	2 years from 1st October 1960.
Prof. J. E. G. Raymont	Mass culture of marine algae.	425	Supplementing a previous grant of £800.
Prof. E. J. Richards	Investigation of turbulence in air jets and in boundary layers.	7 400	3 years from 1st October 1959
Prof. E. J. Richards	Cumulative damage laws in structural fatigue.	1 810	2 years from 1st October 1959
Dr. J. R. Rydzewski	Model studies of arch dams.	3 594	2 years from 1st January 1960
Dr. G. Shelton	The nervous co-ordination of fish breathing.	663	1 year from 1st October 1960
Dr. M. C. R. Symons	Studies in the visible and ultra-violet range.	674	1 year from 1st June 1959
Dr. M. C. R. Symons	Unstable intermediates.	3 221	1 year from 1st January 1960
Dr. M. C. R. Symons	A study of unstable intermediates.	2 880	3 years from 1st January 1961
Mr. S. Weintroub	Physical properties of metal single crystals.	3 500	2 years from 1st October 1960
UNIVERSITY OF WALES *University College of Wales Aberystwyth*			
Prof. W. J. G. Beynon	Radio studies of the upper atmosphere.	3 000	4 years from 1st October 1959
Prof. W. J. G. Beynon	A study of geomagnetic distortion in the ionosphere.	510	1 year from 1st July 1960
Dr. M. M. Davies	High frequency dielectric studies in relation to molecular structure.	5 355	1 year from 1st October 1957
Dr. H. Jones	Translocation of assimilates in tobacco plants using radioactive CO_2.	314	1¼ years from 1st October 1956
Dr. H. Jones	Translocation of ^{14} carbon.	1 872	3 years from 1st October 1959
Dr. W. J. Orville-Thomas	Dispersion studies in the infra-red spectral region.	5 309	1 year from 1st October 1960
Prof. A. F. Trotman-Dickenson	Reactions of free radicals in gases.	2 745	1 year from 1st October 1960
Prof. P. F. Wareing	Nature of the growth inhibitors present in plant tissues.	1 150	2 years from 1st October 1959

Investigator	Subject	Grant £	Period Covered
UNIVERSITY OF WALES—*contd.*			
University College of North Wales, Bangor			
Prof. E. R. Andrew ..	High resolution nuclear magnetic resonance.	14 500	1 year from 1st October 1960
Dr. D. J. Crisp	Marine fouling in British waters.	1 700	Supplementing a previous grant of £1950
Dr. D. J. Crisp	Hydrography of ports and estuaries.	12 950	5 years from 1st October 1960
Mr. R. I. Davies ..	Organo-metallic complexes in soils and plants.	2 412	3 years from 1st October 1960
Prof. W. C. Evans ..	Microbial metabolism of aromatic compounds.	690	1 year from 1st October 1959
Prof. M. R. Gavin and Mr. F. J. Hyde	Parametric amplification.	7 810	3 years from 1st May 1960
Mr. F. Holmes	Thermodynamics of complex formation between transition metal ions and heterocyclic ligands.	980	1 year from 1st October 1960
Mr. F. J. Hyde	Transistor research at radio frequencies.	5 000	3 years from 1st November 1958
Mr. G. A. D. Jackson ..	Accumulation of ascorbic acid in rose hips.	822	1 year from 1st October 1959
Mr. A. R. Owens ..	Millimicrosecond pulse techniques using semiconductors.	2 447	3 years from 1st October 1960
Mr. D. W. Parry ..	Microscopical studies of the opaline silica bodies in grasses.	350	1 year from 1st October 1959
Dr. T. B. Reynoldson ..	Ecology of lake-dwelling triclads.	1 940	3 years from 1st July 1960
University College of South Wales and Monmouthshire, Cardiff			
Mr. L. H. Butler ..	Friction and deformation of contacting surfaces under pressure.	700	1 year from 1st September 1960
Prof. A. G. Evans ..	Solvents and ionization reactions.	1 140	1 year from 1st May 1958
Prof. A. G. Evans ..	Activation of carbon-carbon double bonds by metal complex catalysts.	4 350	1 year from 1st February 1960
Mr. R. D. Garwood ..	The rôle of structural imperfections and grain boundaries in the mechanism of phase transformations in metals and alloys.	9 600	1 year from 1st October 1960
Mr. E. C. Hill	Physiology of irradiated microorganisms.	500	1 year from 1st January 1959
Mr. W. H. Powell ..	The assessment of noise in coal mines.	280	1 year from 1st August 1957
Prof. A. J. C. Wilson ..	Measurement of accurate lattice parameters by a counter diffractometer.	1 390	1 year from 1st January 1959
Prof. A. J. C. Wilson ..	X-ray investigation of crystal and molecular structures. .	1 605	1 year from 1st April 1960
University College of Swansea			
Dr. D. E. Davies.. ..	Formation of chromic acid on metal surfaces.	1 042	$1\frac{11}{12}$ years from 1st February 1959
Prof. F. L. Jones ..	Ionization, electrical contact phenomena.	1 000	1 year from 1st September 1957

Investigator	Subject	Grant £	Period Covered
Mr. J. A. Sandover ..	An investigation of surge wave profiles in open channel flow.	1 050	1½ years from 1st March 1957
Mr. J. A. Sandover ..	Undular surges in prismoidal channels.	360	1 year from 1st November 1958
Prof. H. E. Street ..	Establishment of free-cell cultures and of the conditions essential for the division of isolated cells derived from vascular plants.	3 975	3 years from 1st October 1960
Dr. R. M. Wood.. ..	Transient behaviour of continuously operating plant.	5 000	1 year from 1st May 1960
SCOTLAND			
ABERDEEN UNIVERSITY			
Prof. G. M. Burnett and Dr. H. F. W. Taylor ..	Isotactic polymers.	3 075	1 year from 1st October 1958
Dr. A. D. Dickson ..	Cytochemical study of the mouse ovum.	687	1 year from 1st June 1959
Prof. R. V. Jones ..	A study of the production and properties of rolled metal foil.	3 800	3 years from 1st October 1957
Prof. R. V. Jones ..	Growth of crystals.	23 600	5 years from 1st February 1960
Prof. J. L. Malcolm ..	Electron microscopy of biological tissues and cell parts.	18 045	3 years from 1st January 1961
Dr. D. C. McKean ..	Spectroscopy in the far infra-red	1 500	2 years from 1st October 1957
Dr. J. W. Porteous ..	Nutrition and metabolism of Actinomyces Israeli.	440	2 years from 1st October 1960
Mr. R. G. Smith ..	Technique on reliability of scale models of concrete structures.	1 500	1 year from 1st October 1960
Prof. P. E. Weatherley ..	Study of the mechanism of translocation in plants.	3 030	3 years from 1st October 1960
EDINBURGH UNIVERSITY			
Mrs. K. M. G. Adam ..	Studies on the growth of soil amoebae.	1 000	2 years from 1st January 1960
Dr. C. A. Beevers ..	X-ray crystallography of sugar phosphates.	5 058	1 year from 1st June 1959
Prof. R. Brown ..	Physiology and biochemistry of cell division and cell expansion.	9 200	2 years from 1st October 1959
Prof. R. Brown ..	Cytoplasmic structure in growing and dividing cells.	14 755	3 years from 1st May 1960
Dr. G. R. Evans ..	Measurement of the velocity of nuclear particles.	2 500	2 years from 1st January 1959
Prof. N. Feather ..	Direct measurement of the g-factor of free electrons.	1 500	1 year from 1st October 1958
Prof. N. Feather ..	Direct measurement of the g-factor of free electrons and positrons.	2 235	1 year from 1st October 1959
Prof. E. L. Hirst ..	Researches in the field of organic chemistry.	1 600	1 year from 1st January 1960
Dr. M. R. W. Johnson	Study of the Moine series, Argyll, Scotland.	200	2 years from 1st January 1960
Dr. E. L. P. Mercy ..	Distribution of elements in co-existing felspar phases in metamorphic and igneous rocks of Western Scotland.	5 606	1 year from 1st January 1961
Dr. N. Miller	A study of the gamma-radiolysis of simple hydrocarbons in the liquid and solid phases.	909	1 year from 1st August 1957

Investigator	Subject	Grant £	Period Covered
EDINBURGH UNIVERSITY—*contd.*			
Dr. J. M. Mitchison	Growth of individual yeast cells.	1 725	3 years from 1st October 1959
Dr. J. M. Mitchison	Synthesis during the cell cycle.	1 050	3 years from 1st January 1961
Dr. F. J. C. Rossotti and Dr. D. Taylor	(*a*) Paramagnetism and complex formation in solution (*b*) electronic factor in catalysis.	922	1 year from 1st January 1960
Dr. M. J. Smyth	Narrow band stellar photometry through interference filters.	750	1 year from 1st January 1960
Prof. M. M. Swann and Dr. A. W. G. Manning	Behaviour patterns in drosophila.	2 700	3 years from 1st October 1959
GLASGOW UNIVERSITY			
Mr. J. R. Atkinson	Photodisintegration of oxygen.	310	6 months from 1st July 1958
Prof. P. I. Dee	Maintenance of synchrotron.	22 700	1 year from 1st August 1957
Prof. P. I. Dee	Maintenance of synchrotron.	29 143	1 year from 1st August 1958
Prof. P. I. Dee	Maintenance of synchrotron.	22 250	1 year from 1st August 1959
Prof. P. I. Dee	Maintenance of synchrotron.	24 400	1 year from 1st August 1960
Prof. P. I. Dee	X-ray scattering by nuclei.	970	1 year from 1st April 1958
Prof. P. I. Dee	Automatic scanner for nuclear emulsions.	1 600	$1\frac{1}{4}$ years from 1st April 1958
Prof. P. I. Dee	Cross sections for the production of π^+ and π^- mesons by gamma rays.	6 000	1 year from 1st January 1959
Prof. P. I. Dee	Development of special measuring equipment for anaylsis of bubble chamber photographs.	3 795	2 years from 1st June 1959
Dr. G. Leaf	Nitrogen metabolism in plants.	2 000	1 year from 1st October 1959
Mr. N. S. Miller	Fairing of ship lines.	3 225	2 years from 1st September 1960
Dr. R. I. Reed	Mass spectrometric study of organic molecules.	22 100	3 years from 1st January 1960
Dr. S. J. Thomson	Radiochemical tracer techniques for study of chemisorption and catalysis.	4 775	4 years from 1st January 1958
THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY, GLASGOW			
Dr. J. A. Blain	Unsaturated fat oxidase activity in seeds and other plant tissues.	800	3 years from 1st September 1957
Dr. A. J. Hyde	Light scattering studies.	1 900	1 year from 1st October 1960
Dr. L. Jacob, et al	Heavy current discharges in gases.	2 300	3 years from 1st January 1960
Prof. R. D. Ritchie	Study of thermal breakdown mechanism of high polymer systems.	1 410	1 year from 1st June 1959
ST. ANDREWS UNIVERSITY			
Prof. E. G. Cullwick	Magnetism and electron kinetic energy.	1 500	$1\frac{9}{12}$ years from 1st October 1957

Investigator	Subject	Grant £	Period Covered
Prof. E. Finlay Freundlich	Observations of the Red-shift of the spectral lines of the sun with tower telescope of Arcetri, Italy.	2 450	3 years from 1st October 1957
Prof. E. Finlay-Freundlich (subsequently transferred to Prof. D. W. Stibbs) ..	Radio echo investigations of the aurora	1 550	2 years from 1st October 1958
Prof. E. Finlay-Freundlich	Schmidt-Cassegrain telescope	2 650	Supplementing previous grant of £9000
Dr. F. D. Gunstone ..	Fatty acids and their natural derivatives.	595	1 year from 1st October 1959
Dr. J. G. Iball	Crystal and molecular structure of organic compounds.	4 275	3 years from 1st October 1959
Mr. I. G. Main ..	Nuclear studies using the photographic emulsion technique.	600	1 year from 1st January 1959
Prof. D. W. N. Stibbs ..	Photometric investigation of nebulosites and extra-galactic nebulae.	2 500	1 year from 1st October 1960
Prof. A. D. Walsh ..	A study of the chemiluminescence accompanying oxidation and allied reactions.	3 010	3 years from 1st October 1957
Prof. A. D. Walsh ..	A study of the ultra-violet absorption spectra of polyatomic molecules under high dispersion.	2 150	3 years from 1st October 1957
Prof. A. D. Walsh ..	The ultra violet absorption spectra of boron compounds.	1 500	2 years from 1st October 1958
Prof. A. D. Walsh ..	Application of wave mechanics to the calculation of atomic and molecular wave mechanics.	1 070	1 year from 1st October 1959
NORTHERN IRELAND QUEEN'S UNIVERSITY OF BELFAST			
Mr. M. J. B. Clarricoats	Propagation behaviour of wave-guides containing ferrites and dielectrics	1 255	3 years from 1st October 1959
Prof. H. B. Henbest ..	Mechanisms and stereo-chemistry of the reactions of organic compounds.	840	1 year from 1st October 1958
Prof. H. B. Henbest ..	Quinones in oxidation and replacement reactions.	2 800	1 year from 1st January 1960
Prof. H. B. Henbest ..	Mechanism and stereo-chemistry of olefin addition reactions.	695	1 year from 1st January 1960
Prof. C. Kemball ..	A study of heterogeneous catalysis using mass spectrometric techniques.	11 000	3 years from 1st October 1957
Dr. H. Mackle	Construction of an aneroid moving-bomb calorimeter.	850	1 year from 1st January 1960
Dr. W. D. Ryan	Problems relating to a portable scintillation recorder.	1 870	3 years from 1st October 1960
Mr. J. G. Stuart	Behaviour of piles and pile groups in sand.	1 940	2 years from 1st September 1957
Prof. J. C. West ..	Non-linear automatic control systems.	5 640	3 years from 1st May 1958

TECHNICAL COLLEGES

Investigator	Subject	Grant £	Period Covered
BATTERSEA COLLEGE OF TECHNOLOGY			
Dr. P. Charsley	Measurement of the thermal conductivity of metals at low temperatures.	955	2 years from 1st January 1960

Investigator	Subject	Grant £	Period Covered
BATTERSEA COLLEGE OF TECHNOLOGY—*contd.*			
Mr. P. R. Doidge ..	Changes in electrical resistivity of aluminium at very low temperatures.	1 100	2 years from 1st January 1959
Dr. J. E. Salmon ..	Ion-exchange studies of complex ions.	3 370	1 year from 1st January 1961
BELFAST COLLEGE OF TECHNOLOGY			
Mr. F. W. Cox and Mr. H. J. Dorman	The drying of flax yarn during manufacture.	385	1 year from 1st October 1960
BIRMINGHAM COLLEGE OF ADVANCED TECHNOLOGY			
Dr. J. D. Butler	Semi-conducting properties of transition metal oxides.	325	1 year from 1st October 1959
Dr. E. Downham ..	Natural vibrations and critical whirling speeds of rotating shaft-rotor systems.	3 100	2 years from 1st October 1959
Dr. A. W. Downs ..	Studies on the structure and properties of nickel amine thiocyanates.	650	1 year from 1st August 1960
Dr. F. M. Page ..	Studies on the mechanism of the formation of ions in flames.	535	1 year from 1st October 1960
Mr. P. J. Stoward ..	Thermodynamics and other biophysical aspects of bacterial growth.	675	2 years from 1st November 1958
BOROUGH POLYTECHNIC, LONDON			
Mr. J. F. Douglas ..	Causes of structural failure in dental plates of acrylic resin.	2 185	3 years from 1st October 1959
BRADFORD INSTITUTE OF TECHNOLOGY			
Mr. R. Steadman ..	Structure analysis of intermediate phases in transition metal alloys.	830	1 year from 1st May 1960
BRIGHTON TECHNICAL COLLEGE			
Mr. F. A. J. Talman ..	Measurement of the repulsive forces between particles in fluid suspension.	1 082	3½ years from 1st August 1959
BRUNEL COLLEGE OF TECHNOLOGY			
Dr. J. M. Skellon ..	Research in lipid chemistry.	3 750	3 years from 1st September 1961
CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY			
Dr. E. M. Brown ..	Researches on protozoa.	2 050	2 years from 1st June 1960
COLLEGE OF AERONAUTICS, CRANFIELD			
Prof. A. J. Kennedy ..	Sensitivity of microcreep to fatigue damage in metals.	3 695	3 years from 1st October 1960
Prof. J. Loxham	Research in machine tool design and utilisation.	18 000	2 years from 1st February 1960
DERBY AND DISTRICT TECHNICAL COLLEGE			
Dr. C. M. Atkinson ..	Reactions of new nitrogen heterocyclic compounds.	3 000	1 year from 1st October 1959

Investigator	Subject	Grant £	Period Covered
DUNDEE TECHNICAL COLLEGE			
Mr. I. R. McGregor ..	Preparation of ultra pure metals.	600	1 year from 1st September 1958
CITY OF GLOUCESTER TECHNICAL COLLEGE			
Dr. C. G. Silcocks ..	The kinetics of thermal decomposition and polymerization of hydrocarbons.	600	1 year from 1st October 1957
LEICESTER COLLEGE OF SCIENCE AND TECHNOLOGY			
Dr. S. Walker	Small polyatomic radicals.	1 435	1 year from 1st October 1958
Dr. E. Ward	Synthesis of dinaphthylenes.	850	2 years from 1st September 1958
LIVERPOOL COLLEGE OF TECHNOLOGY			
Dr. G. G. Jayson and Mr. J. W. Lucas	Radiation chemistry of compounds of biological importance and allied topics.	3 595	1 year from 1st October 1960
Mr. R. J. Newcombe ..	Oscilloscopic and mechanistic studies at an expanding mercury surface.	1 944	2 years from 1st October 1960
Dr. D. W. Parkin ..	Collection and examination of cosmic dust.	4 049	5 years from 1st January 1960
MONMOUTH TECHNICAL COLLEGE			
Dr. T. V. Starkey ..	Mechanism of viscosity shear dependance and related phenomena in suspensoid sols.	2 500	3 years from 1st September 1959
NEWPORT AND MONMOUTH COLLEGE OF TECHNOLOGY			
Mr. L. A. Jones ..	Stresses in rolling mill housings.	100	2 years from 1st January 1959
NORTHAMPTON COLLEGE, LONDON			
Dr. D. J. Alner ..	pH values and buffer solutions.	350	1 year from 1st September 1960
NORWOOD TECHNICAL COLLEGE			
Dr. W. F. Williams ..	Behaviour of positronium in gases.	995	1 year from 1st January 1959
Dr. W. F. Williams ..	Quenching of orthopositronium in gases.	825	1 year from 1st October 1959
PADDINGTON TECHNICAL COLLEGE			
Mr. W. Craven	High rate of heat transfer with nucleate boiling to fluids in rectangular section tubes heated on one face.	500	2 years from 1st January 1960
PLYMOUTH TECHNICAL COLLEGE			
Dr. D. R. Glasson and Dr. A. B. Meggy	Preparation of active solids.	1 000	1 year from 1st October 1958
PORTSMOUTH COLLEGE OF TECHNOLOGY			
Mr. A. Mason	Flux and energy spectrum of primary cosmic ray particles.	650	1 year from 1st January 1959

Investigator	Subject	Grant £	Period Covered
THE POLYTECHNIC, REGENT STREET, LONDON			
Mr. T. Yarwood and Mr. F. A. Baker	Mechanisms involved in the electrical clean-up and sorption of gases at very low gas pressures.	500	3 years from 1st October 1959
ROTHERHAM COLLEGE OF ADVANCED TECHNOLOGY			
Mr. D. Yarnton ..	Effect of dispersal phase hardening on the properties of metal powder compacts.	3 115	3 years from 1st January 1959
ROYAL TECHNICAL COLLEGE, SALFORD			
Dr. A. W. J. Chisholm	Machining tests.	13 185	2 years from 1st October 1960
Dr. J. Wilkinson ..	Ionizing radiation and chemical systems.	640	1 year from 1st May 1958
SIR JOHN CASS COLLEGE			
D. C. Ayres	Cancer inhibiting lignans.	350	2 years from 1st January 1960
Dr. D. B. Powell and Dr. R. F. White	Structural studies and molecular interaction effects in inorganic systems.	18 753	3 years from 1st May 1960
SOUTH WEST ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART			
Dr. S. Lewin	Interaction of DNA and RNA with formaldehyde and aldoses.	7 110	2 years from 1st October 1960
TAUNTON TECHNICAL COLLEGE			
Mr. B. E. Stacey and Dr. L. Hough	Polysaccharides in green leaves.	253	2 years from 1st May 1958
WELSH COLLEGE OF ADVANCED TECHNOLOGY			
Dr. D. P. Hutchinson ..	An experimental investigation into the ignition and combustion of drops of fuel oil in a hot air air stream.	950	1 year from 1st August 1957
WEST HAM COLLEGE OF TECHNOLOGY			
Dr. W. E. Stein	Fractional distillation.	600	1 year from 1st October 1957
	MISCELLANEOUS		
BRITISH SCHOOL OF ARCHAEOLOGY			
Dr. K. Kenyon	Human skeletal remains at Jericho.	400	1 year from 1st October 1957
PRIVATE OBSERVATORY, ASCOT			
Dr. R. L. Waterfield ..	Study of the physical features of comets.	600	2 years from 1st January 1959
THE RADCLIFFE OBSERVATORY, PRETORIA, SOUTH AFRICA			
Radcliffe Trustees (Dr. R. v. d. R. Woolley) ..	Intensive photometry of Southern sky.	30 000	5 years from 1st October 1957

Investigator	Subject	Grant £	Period Covered
ROYAL MILITARY COLLEGE OF SCIENCE, SHRIVENHAM			
Prof. A. Charlesby	Radiation protection effects in irradiated polymer solution.	5 522	3 years from 1st October 1959
Prof. J. H. Turnbull	Excited states of biological molecules.	3 515	3 years from 1st October 1960

(ii) Human Sciences

Investigator	Subject	Grant £	Period Covered
BIRMINGHAM UNIVERSITY			
Prof. N. A. Dudley	Principles of Batch Production.	3 930	2 years from 1st April 1960
BRISTOL UNIVERSITY			
Prof. K. R. L. Hall	Complexity of Industrial Tasks.	35 084	5 years from 1st August 1960
CAMBRIDGE UNIVERSITY			
Mr. R. L. Gregory	Development of Special Devices.	3 086	1 year from 1st October 1958
Mr. R. L. Gregory	Development of Special Devices.	9 498	3 years from 1st October 1959
LEICESTER UNIVERSITY			
Dr. I. Neustadt	Women in a Hosiery Factory	3 961	2 years from 1st April 1960
LIVERPOOL UNIVERSITY			
Dr. W. H. Scott	Automation and the non-Manual Worker.	15 578	3½ years from 1st April 1960
LONDON UNIVERSITY BIRKBECK COLLEGE			
Mr. T. A. Rodger	Hollerith Card Scanning.	310	1 year from 1st October 1958
Mr. T. A. Rodger	Vocational Guidance Interviewing.	285	3 years from 1st October 1958
Mr. T. A. Rodger	Testing Manipulative Skill.	70	2 years from 1st October 1960
LONDON SCHOOL OF ECONOMICS			
Prof. D. V. Glass	Careers of Undergraduates.	16 536	3 years from 1st June 1958
Prof. R. M. Titmuss	Women in a Hosiery Factory.	2 025	1½ years from 1st January 1959
Miss B. N. Seear	The Nature of Supervisory Tasks.	3 450	1 year from 1st January 1959
Dr. Hilde Himmelweit	Vocational Adjustment.	9 463	3 years from 1st September 1960
UNIVERSITY COLLEGE			
Prof. G. C. Drew	Training of Skilled Operatives.	6 100	1 year from 1st January 1959
Prof. G. C. Drew	Muscular Skill.	1 090	9 months from 1st January 1959
MANCHESTER UNIVERSITY (Transferred to Birmingham College of Advanced Technology)			
Dr. T. Lupton	Individual Performance.	29 450	5 years from 1st April 1960
MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY			
Dr. A. Roberts	Management and Technical Charge.	450	1 year from 1st January 1959

Investigator	Subject	Grant £	Pediod Covered
OXFORD UNIVERSITY			
Mr. H. Tajfel	Quantitative Judgements.	3 400	3 years from 1st October 1959
Prof. H. Kay	High Speed Performance.	1 500	1 year from 1st October 1959
READING UNIVERSITY			
Prof. M. D. Vernon	Reading Efficiency.	400	3 years from 1st January 1958
Dr. E. R. F. W. Crossman	Plant Operator skills.	8 550	3 years from 1st January 1959
SHEFFIELD UNIVERSITY			
Prof. R. K. Kelsall	School to work in Sheffield.	6 903	3 years from 1st October 1958
Prof. H. Kay	Industrial Skills.	15 645	3 years from 1st October 1960
CARDIFF, UNIVERSITY COLLEGE			
Prof. M. P. Fogarty	Technical Change.	1 165	1 year from 1st April 1958
EDINBURGH UNIVERSITY			
Mr. T. Burns	Management of Innovation.	225	6½ months from 10th December 1957
Mr. T. Burns	Working Organization.	6 645	3 years from 1st October 1960
Prof. J. Drever	The rejection Threshold in Inspection.	1 865	2 years from 1st January 1958
GLASGOW UNIVERSITY			
Dr. C. Jahoda	The perceived rôle of Youth Employment Officers.	342	2 years from 1st September 1960
BRUNEL COLLEGE			
Mr. L. F. Thomas	Inspection and Quality Control.	4 875	3 years from 1st October 1959
THE POLYTECHNIC, REGENT STREET, LONDON			
Dr. S. F. Cotgrove	Training of Technicians.	80	1 year from 1st October 1960
ACTON SOCIETY TRUST			
Miss R. Stewart	Management Initiative.	5 950	2 years from 1st June 1958
Miss R. Stewart	Management Behaviour.	6 155	2 years from 1st April 1960
ROYAL INSTITUTE OF PUBLIC ADMINISTRATION			
Mr. R. F. T. Nottage	Operational Research.	4 200	2 years from 1st July 1959
TAVISTOCK INSTITUTE OF HUMAN RELATIONS			
Mr. E. L. Trist	Socio-Technical Systems.	17 060	2 years from 1st January 1959

(iii) Space Research

These Research Grants authorized in 1956–60 are paid through D.S.I.R. on the recommendation of the British National Committee on Space Research of the Royal Society.

Investigator	Subject	Grant £	Period Covered
BIRMINGHAM UNIVERSITY			
Prof. J. Sayers	Electron and ion population studies in the upper atmosphere and interplanetary space.	26 000	3 years from 1st April 1960
CAMBRIDGE UNIVERSITY			
Dr. K. G. Buddon ..	The theory of propagation of radiation from artificial satellites.	1 694	2 years from 1st April 1960
Prof. M. Ryle	Recording and interpretation of Doppler and Faraday effects in the radiations from artificial satellites.	2 678	2 years from 1st April 1960
Dr. F. G. Smith ..	Measurement of cosmic radio noise by receivers mounted on rockets and satellites.	11 230	3 years from 1st October 1959
LEICESTER UNIVERSITY			
Prof. E. A. Stewardson ..	An investigation of solar and stellar soft X-ray emissions.	13 006	3¼ years from 1st January 1960
LONDON UNIVERSITY			
Imperial College			
Prof. H. Elliot	Satellite measurements of primary cosmic ray energy spectrum.	7 275	2 years from 1st January 1960
Prof. H. Elliot	Cosmic ray intensity variations at rocket altitudes.	1 500	2 years from 1st April 1960
Dr. S. H. Hall	Geomagnetic field measurements in the earth's upper atmosphere.	7 935	3 years from 1st April 1960
Dr. S. H. Hall	Magnetic field measurements with a satellite magnetometer.	4 535	3 years from 1st July 1960
Prof. J. D. McGee ..	Development of photo-electronic image intensifiers suitable for use in earth satellites.	17 115	3 years from 1st June 1960
Prof. J. D. McGee ..	The use of photo-electronic image intensifiers for tracking.	7 920	3 years from 1st June 1960
University College			
Dr. R. L. F. Boyd ..	Satellite research.	57 700	3 years from 1st December 1959
Dr. R. L. F. Boyd ..	The development and use of photoelectric satellite tracking equipment.	8 880	3 years from 1st April 1960
Dr. R. L. F. Boyd ..	Rocket research in the upper atmosphere.	35 450	3 years from 1st April 1960
Dr. G. V. Groves ..	Analysis of rocket and satellite data.	3 420	1¼ years from 1st April 1960
Dr. G. V. Groves ..	Theoretical studies relating to the use of rockets and satellites and the data obtained thereby.	2 085	2 years from 1st September 1960
MANCHESTER UNIVERSITY			
Dr. R. C. Jennison ..	Micrometeorite investigations from an earth satellite.	15 277	3⅓ years from 1st November 1959
Dr. R. C. Jennison ..	Low frequency radio astronomy from an earth satellite.	15 020	3⅔ years from 1st August 1959
Prof. Sir Bernard Lovell	Tracking of satellites and space probes.	2 500	1 year from 1st April 1960
OXFORD UNIVERSITY			
Dr. J. T. Houghton ..	Investigation of infra-red detectors for satellite measurements.	4 560	1½ years from 1st July 1960

Investigator	Subject	Grant £	Period Covered
READING UNIVERSITY			
Dr. S. D. Smith	Infra-red interference filters for satellite meteorological experiments.	5 050	1 year from 1st August 1960
SHEFFIELD UNIVERSITY			
Dr. T. R. Kaiser ..	Measurement of V.L.F. radiation in interplanetary space.	14 728	3 years from 1st October 1960
WALES—UNIVERSITY COLLEGE ABERYSTWYTH			
Prof. W. J. Beynon ..	Radio propagation experiments with rockets.	16 530	3 years from 1st April 1960
NORTHERN IRELAND QUEEN'S UNIVERSITY, BELFAST			
Prof. D. R. Bates ..	Upper atmosphere rocket research.	15 455	2 years from 1st April 1960

Glossary

(Mainly of Administrative Terms Used Repeatedly in the Report)

Advisory Council

The Order in Council of 28th July 1915 instituted an Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research; and the Order was revoked by the Department of Scientific and Industrial Research Act, 1956.

Advisory Council on Scientific Policy (A.C.S.P.)

The A.C.S.P. advises the Minister for Science in the exercise of his responsibilities for the formulation and execution of Government scientific policy. It was set up in 1947 and its membership includes the heads of the principal Government scientific organizations and a number of eminent scientists from outside the Government Service.

Agricultural Research Council (A.R.C.)

The Agricultural Research Council, which was established by Royal Charter in 1931, is responsible for the organization and development of agricultural and food research and makes grants for investigations and research relating to the advancement of agriculture.

C.E.R.N.—The European Organization for Nuclear Research

C.E.R.N. was established in 1954 under an Inter-Governmental Convention to enable European states to collaborate in high-energy nuclear research. The Organization's laboratories are at Meyrin, near Geneva, where two particle accelerators have been constructed: a 600 MeV synchrocyclotron and a 28 GeV proton-synchrotron, this latter machine being among the most powerful and successful in the world. The laboratories have a staff of over a thousand, drawn in the main from nationals of the fourteen member states.

Colleges of Advanced Technology (C.A.T.s.)

These colleges provide comprehensive courses on a wide range of subjects at an advanced level only, including postgraduate and research work. To qualify for designation as a C.A.T. a college must fulfil certain conditions regarding the constitution of its governing body, staffing, accommodation and so forth, prescribed by the Minister of Education. There are at present ten C.A.T.s.—Birmingham College of Advanced Technology; Bradford Institute of Technology; Bristol College of Science and Technology; London—Battersea College of Technology, Brunel College of Technology, Acton, Chelsea College of Science and Technology; Northampton College of Advanced Technology; Loughborough College of Technology; Royal College of Advanced Technology, Salford; Welsh College of Advanced Technology, Cardiff.

Conditional Aid

Conditional Aid stemmed in 1953 from the U.S.A. post-war "Marshall Aid" plan under which dollars were offered on condition that recipient countries established equal "counterpart" funds in local currency to be spent on the encouragement of a healthy and expanding economy by promoting industrial productivity and stimulating competition.

Contract

In this report a D.S.I.R. "research contract" denotes the agreement under which research is commissioned at a university by D.S.I.R. as part of the Department's own research programme. It should not be confused with a D.S.I.R. "research grant" (q.v.) which refers to a grant sought by a university to aid research the university is initiating.

Council for Scientific and Industrial Research

Under the Department of Scientific and Industrial Research Act, 1956, the Department was placed in the charge of a Council for Scientific and Industrial Research (the Research Council). This Council superseded the Advisory Council for Scientific and Industrial Research (q.v.), a purely advisory body which had been in existence since 1915, the year before the Department was formed.

Diploma in Technology (Dip. Tech.)

The Dip. Tech. is awarded by the National Council for Technological Awards (q.v.) to students in colleges of advanced technology and other technical colleges who successfully complete higher technological courses approved by the Council. It is equivalent in academic standard to a British university honours degree and is accepted by D.S.I.R. for the purpose of its studentship schemes.

Ergonomics

Ergonomics has been broadly defined as "fitting the job to the worker". This includes studies of equipment design, layout of workplace, machine control, and the capacities of men in relation to the design of machines. Similar studies are described in America by the term "human engineering".

European Productivity Agency (E.P.A.)

The Agency was set up in 1953 under the aegis of the Organization for European Economic Co-operation (q.v.) to promote productivity in a number of fields in member countries. Many of its interests have now been taken over by the recently formed Organization for Economic Co-operation and Development (q.v.).

Human Sciences

This term is at present used by D.S.I.R. to cover broadly psychology, sociology and social anthropology. The phrase occurs in the name of the Human Sciences Committee of the Research Council and the Human Sciences Section of the Grants Division of D.S.I.R. Clinical, animal and education psychology and aspects of sociology and social anthropology unrelated to the actual or potential needs of industry are, however, outside the field within which D.S.I.R. can give support.

Medical Research Council (M.R.C.)

The Medical Research Council (formerly Committee) was incorporated under its present title by Royal Charter in 1920 to administer funds from public and private sources for the promotion of medical research.

Membership of the College of Technologists (M.C.T.)

This award, higher than the Diploma in Technology (q.v.), was instituted in 1959 by the National Council for Technological Awards (q.v.) and is administered by the College of Technologists. The standard of the award is broadly equivalent to the Ph.D. degree of a university and is intended as a mark of outstanding distinction for the student who has completed a substantial programme of work demanding the application of his knowledge to the solution of a problem related to the needs of industry.

National Council for Technological Awards

The Council was established in 1955 by the Minister of Education as an independent self-governing body to create and administer awards for students in technical colleges. The first Chairman of the Council, Lord Hives, was succeeded in 1960 by the present Chairman (now also Chairman of the Research Council) Sir Harold Roxbee Cox.

National Institute for Research in Nuclear Science (N.I.R.N.S.)

The N.I.R.N.S. was constituted in 1957 with the main object of providing in nuclear physics research for common use by universities and others, facilities and equipment which are beyond the scope of individual universities and institutions. The Institute's first laboratory is the Rutherford High Energy Laboratory, Harwell.

National Research Development Corporation (N.R.D.C.)

A public corporation established in 1949 by the Board of Trade to develop and exploit inventions in the public interest, and to acquire, hold, dispose and grant rights in inventions as the public interest requires.

Nature Conservancy

The Nature Conservancy are a corporation, incorporated by Royal Charter in 1949, to provide the Government with scientific advice on the conservation and control of the natural flora and fauna of Great Britain; to establish, maintain and manage nature reserves in Great Britain, including the maintenance of physical features of scientific interest; and to organize and develop the research and scientific services related thereto. Certain statutory powers have also been conferred on the Conservancy by the National Parks and Access to the Countryside Act, 1949, and subsequent legislation.

Organization for Economic Co-operation and Development (O.E.C.D.)

The O.E.C.D. came into being in 1961 with the United States and Canada as full members in addition to the countries of the former O.E.E.C. Its purposes are to promote the economic growth of member countries, to help member and non-member countries in the process of economic development, and to contribute to the expansion of world trade.

Organization for European Economic Co-operation (O.E.E.C.)

The O.E.E.C. was formed in 1948 to assist the U.S. European Recovery Programme in drawing up and executing a programme for European recovery by encouraging co-operation in economic, financial and technical matters. Many of its aims have now been transferred to the newly formed Organization for Economic Co-operation and Development (O.E.C.D.).

Research Association

A co-operative, non-profit making research body designed to carry out scientific and technological research for a particular section of industry. More than fifty of these associations now exist, covering a wide range of products and processes. They are financed and controlled by members from the industries concerned, but most of them also receive grants from D.S.I.R.

Research Council (D.S.I.R.)

Research Council is the customary abbreviated form, sanctioned in the D.S.I.R. Act, 1956, of the "Council for Scientific and Industrial Research" (q.v.)

(The) Research Councils

The Research Councils are four bodies, namely D.S.I.R., the Agricultural Research Council, the Medical Research Council and the Nature Conservancy. They are all responsible to the Minister for Science.

Research Grant

A D.S.I.R. "research grant" (formerly known as a grant for a special research) is a grant made by D.S.I.R. to enable an investigator of acknowledged standing (usually in a university or college) to initiate and develop an investigation of timeliness and promise upon which he will be engaged, or to enter promising new or modified fields of research or to take advantage of developments in apparatus. Unlike a "contract" (q.v.), a research grant is made in response to an application from a university scientist.

State Scholarships

State Scholarships are awarded by the Ministry of Education to undergraduate students to enable them to read for a first degree in either arts or science at a university.

1962

State Studentships

State Studentships are awarded by the Ministry of Education to graduates in the arts to enable them to undertake research or advanced study normally leading to a higher degree in such arts-subjects as classics, philosophy, modern languages, etc.

Training Award

"Training Award" is the general term used in this report to cover D.S.I.R. Studentships, Advanced Course Studentships, "First Year" Studentships under a trial scheme (page 37), and Research Fellowships.

United Kingdom Atomic Energy Authority (U.K.A.E.A.)

The Authority was set up by the Atomic Energy Authority Act, 1954, to deal with the research, development and production of atomic energy for civil and military purposes.

University Grants Committee (U.G.C.)

The U.G.C. was appointed by the Chancellor of the Exchequer in 1919 and is responsible to him for enquiring into the financial needs of university education in Great Britain, and for advising the Government as to the application of any grants made by Parliament towards meeting them.

Printed in England under the Authority of
Her Majesty's Stationery Office by The Hereford Times Ltd., London and Hereford.
(Ps.108534). Wt. 3375. K18. 8/62.

© *Crown copyright 1962*

Published by
HER MAJESTY'S STATIONERY OFFICE

To be purchased from
York House, Kingsway, London, W.C.2
423 Oxford Street, London W.1
13A Castle Street, Edinburgh 2
109 St. Mary Street, Cardiff
39 King Street, Manchester 2
50 Fairfax Street, Bristol 1
35 Smallbrook, Ringway, Birmingham 5
80 Chichester Street, Belfast 1
or through any bookseller

S.O. Code No. 47-236

DEPARTMENT OF
SCIENTIFIC AND INDUSTRIAL RESEARCH

D.S.I.R., UNIVERSITIES AND COLLEGES 1956-60

A Report on D.S.I.R. Support for Research and Training in Universities and Colleges, 1956–60

1962
CAMBRIDGE

LONDON
HER MAJESTY'S STATIONERY OFFICE
1962

Note

D.S.I.R. grants and awards are made in engineering and other branches of technology as well as in pure and applied science. Except where it is clearly not intended the words "science" and "scientist" in this report may be taken to include "engineering and technology" and "engineer and technologist" respectively. Similarly the word "university" has for the sake of brevity often been used to embrace universities, colleges of advanced technology and other appropriate technical colleges and institutions of advanced learning at which D.S.I.R. grants and awards can be held.

PREFACE

A notable and welcome feature of our national life in recent years has been the growing recognition of the importance of science and technology. In industry, government service and the professions: in universities, colleges and schools: more and more scientists, engineers and technologists are required for work in research, development, production, administration, teaching and services of all kinds. The output of scientists, engineers and technologists from universities, colleges of advanced technology and technical colleges is rising rapidly to satisfy these demands. At the same time in universities and colleges there has been a tremendous upsurge in scientific and technological research which is inseparable from and essential to the highest quality of advanced teaching. This growth of research, both pure and applied, is of great national value. It provides a fund of new knowledge and discovery for science and industry: it makes full use of the wealth of intellectual and experimental skill in the academic world: it lays the foundations of scientific and intellectual training at advanced level upon which the future prosperity of the country depends. In this growing field of activity the Department of Scientific and Industrial Research plays an important part, and the following report gives an impressive account of what has been done during a period of four years to strengthen the academic side of British science.

The Department of Scientific and Industrial Research, together with its sister research councils under the aegis of the Minister for Science, is responsible for a wide range of scientific effort. The Department conducts a substantial amount of basic and applied research in the national interest and encourages applied research in industry in a variety of ways as well as helping research and the training of research workers in universities and colleges. All this work is briefly described in the annual reports of the Council for Scientific and Industrial Research. In addition the national and industrial aspects of D.S.I.R. work are described mainly in the annual reports of its research establishments and in "Research for Industry", which covers the research associations, but this is the first occasion on which our support of science in universities and colleges has been described in a separate publication.

The founders of D.S.I.R. in 1915 foresaw the importance of training in university research and the close integration of this fundamental duty with the promotion of research in the national interest and the encouragement of research in industry. The close interweaving of these triple responsibilities as they have developed has greatly strengthened the total effort of D.S.I.R. The Department is well placed to see the whole pattern of the country's scientific effort and to safeguard the fundamental importance to that effort of the support of research and postgraduate training in universities, colleges of advanced technology and technical colleges which this volume describes.

H. W. MELVILLE,
Secretary

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH
State House,
High Holborn,
London W.C.1.

August, 1962.

CONTENTS

PAGE

Preface . . . iii

Chapter 1. Introduction and Summary

- Activities of D.S.I.R. . . . 1
- Funds for Research in Universities and Colleges . . . 2
- Funds for Postgraduate Training in Universities and Colleges 4
- Financing D.S.I.R. Support . . . 4
- Growth of D.S.I.R. Support . . . 4

Chapter 2. Postgraduate Training Awards. Studentships and Fellowships.

SECTION I. D.S.I.R. SCHEMES

- Purpose . . . 11
- Research Studentships . . . 11
- Research Fellowships . . . 11
- Advanced Course Studentships . . . 11
- Growth of D.S.I.R. Responsibility . . . 11
- Committee Structure . . . 12
- Numbers of Awards . . . 13
- Distribution of Studentships Between Subjects . . . 13
- Studentships held in Reserve . . . 14
- The Quota System for Allotting Studentships . . . 14
- Differences between the Two Schemes of Studentships . . . 14
- Studentships Held Abroad . . . 15
- N.A.T.O. Science Studentships . . . 15
- D.S.I.R. Research Fellowships . . . 16
- N.A.T.O. Science Fellowships . . . 16
- Young U.K. Scientists in North America . . . 17

SECTION II. SOME FACTS AND FIGURES

- Introduction . . . 17
- Growth of the Schemes . . . 17
- Quality of Graduates Awarded D.S.I.R. Studentships . . . 19
- Support of Postgraduate Students in Science and Technology 20
- Subjects in which Awards were Held . . . 22
- Where the Awards were Held . . . 23
- Movement of D.S.I.R. Students between Universities . . . 26
- Migration between Universities . . . 27
- Women Students and Fellows . . . 28
- Ages . . . 28
- Married Students . . . 29
- Earnings of D.S.I.R. Students from Teaching, etc. . . . 30
- Students Living at Home . . . 32
- Students' Careers . . . 32

SECTION III. SOME PROBLEMS OF ADMINISTRATION

- Introduction . . . 33
- Total Numbers of Studentships . . . 33
- Division of Numbers between Subjects . . . 35
- Values of Awards . . . 36
- Periods of Tenure . . . 36
- Standards of Degrees . . . 36
- A Trial Arrangement . . . 37
- Alternatives to Degrees . . . 37

PAGE
Division of Responsibility with Government Bodies . . . 37
Allotment to Small Departments 38
Allotment to Other Institutions 38

SECTION IV. THE VALUE OF AWARDS

Values in 1956–1960 39
Review of the Value of Awards 40
Action on the Ashby Sub-committee's Proposals . . . 41
Abridgement of the Ashby Report 42
General Level of Awards: General Principles 42
Relating Awards to Starting Salaries 43
Engineers 43
Rates for Different Places 44
Students Living at Home 45
Special Allowances and Increments 46
Dependants' Allowances 46
Increments for Older Students 47
Deductions from D.S.I.R. Awards 47
(i) General. 47
(ii) Earnings for Teaching and Demonstrating . . . 48
(iii) Other Earnings 48
(iv) Prizes 48
(v) Scholarships. 48
(vi) Private Incomes 49
(vii) Recommendations 49
Students' Fees 49
Fees other than at Oxford and Cambridge 50
Fees at Oxford and Cambridge 50
Research Fellowships 50
Recommendations on the Value of Fellowships . . . 51
Superannuation of Fellows 52
Relationship between a Fellow and his University or College 52

Chapter 3. Research Grants

SECTION I. THE D.S.I.R. SCHEME

Purpose of Scheme 53
Post-war Expansion 53
Setting up of the Research Grants Committee . . . 53
Composition of the Committee 54
Appointment of Sub-committees 54
Responsibilities of the Sub-committees 54
Planning for the Future 55
The Rôle of the Research Councils 55
Research in Colleges of Advanced Technology and Elsewhere 57

SECTION II. DISTRIBUTION OF RESEARCH EFFORT

Balance between Branches of Science and between Universities 57
Balance of Research Effort in Pure Science 59
Balance of Research Effort in Applied Science and Technology 60
Organizational Problems in Technological Research . . 60
Links with National and Industrial Laboratories . . . 61

SECTION III. LARGE-SCALE RESEARCH FACILITIES

The Problem 62
Types of Equipment 63

PAGE
Sharing of General Service Equipment 63
Sharing of Special Research Equipment 63
Nature of the Research Programme 64
Ability of the Research Workers 64
Organization for Sharing 65
International Collaboration 65
The Future 66

SECTION IV. SOME RECENT DEVELOPMENTS
Longer-Term Renewable Grants 66
Nationality of Applicants 68
Senior Visiting Fellowships 68
O.E.E.C. (now O.E.C.D.) Senior Visiting Fellowships . . 68
Space Research Grants 68
Sounding Rocket Programme 69
Research with Satellites 69

SECTION V. ADMINISTRATIVE AND FINANCIAL ARRANGEMENTS
Dealing with Applications 69
Regulations for Grants 70
Administering the Grants 70
Allocation of Funds 71
Growth of the Demand 71

SECTION VI. REVIEW OF RESEARCH RESULTS
Introduction and Acknowledgement 72
Astronomy 73
Biology 77
Chemistry 82
Geology and Geophysics 85
Low-Temperature and Solid-State Physics 89
Nuclear Physics 95
Other Branches of Physics 108
Technology 113

Chapter 4. Human Sciences
Earlier Interest 118
The Joint Committees 118
Formation of the D.S.I.R. Human Sciences Committee . . 119
Initial Review of Research Needs 119
Fostering of Research Groups 119
Further Review of Research and Training 120
Some Problems Associated with Grants 121
Composition of the Human Sciences Committee . . . 121
Sub-committees 122
(i) Grants 122
(ii) Ergonomics 123
(iii) European Productivity Agency 123
Research Programme 123
Other Activities 124
A Register of Research 124
Inquiries 124
Response to Applications 125

PAGE

Supported Projects . . . 126
Industrial Recruitment . . . 126
Control of Skills . . . 127
Impact of Change . . . 127
Industrial Skills and Training . . . 127
Evaluation of D.S.I.R. Support . . . 127

Chapter 5. Conclusion . . . 129

Appendix A. Department of Scientific and Industrial Research Act, 1956 . . . 131

Appendix B. Terms of Reference and Membership of Committees and Sub-committees: Senior Staff of Grants Division, 31st December, 1960.

1. Terms of Reference . . . 134
    (i) Postgraduate Training Awards Committee . . . 134
    (ii) Sub-committees of the Postgraduate Training Awards Committee . . . 134
    (iii) Research Grants Committee . . . 134
    (iv) Sub-committees of the Research Grants Committee . 135
    (v) Human Sciences Committee . . . 135
    (vi) Sub-committees of the Human Sciences Committee . 136
2. Membership of Advisory Council, Research Council, Committees and Sub-committees . . . 137
    (i) Advisory Council, the Council for Scientific and Industrial Research—D.S.I.R. and Research Council . 137
    (ii) Postgraduate Training Awards Committee and its Sub-committees . . . 138
    (iii) Research Grants Committee and its Sub-committees . 148
    (iv) Human Sciences Committee and its Sub-committees . 157
3. Senior Staff of Grants Division at 31st December 1960. . 160

Appendix C. Statistics: D.S.I.R. Studentships and Fellowships

Notes on Appendix C . . . 161
1. Numbers of D.S.I.R. Studentships and Fellowships 1949–60 162
2. D.S.I.R. Awards held in each University, College, etc. at the beginning of October, 1957–60 . . . 163
3. List of Postgraduate Courses Accepted by D.S.I.R. as Suitable for the Tenure of their Advanced Course Studentships up to December, 1960 . . . 169
4. Movement within U.K. between Universities etc. of D.S.I.R. Students taking up their Studentships: Totals for 1957–60 inclusive . . . 177
5. Sources of Support of Research Students in Science and Engineering in Great Britain; 1958–59: numbers and percentages of Research Students in each subject receiving support from each source . . . 179
6. List of Fellows: D.S.I.R. (and D.S.I.R./N.A.T.O.) Research Fellowships Awarded in 1956–60 . . . 180

PAGE

Appendix D. Statistics and Lists of Research Grants in the Period October 1956 to September 1960

Notes on Appendix D. 184

1. Number and Value of Research Grants Awarded . . 185
2. Number and Value of Applications Considered and Research Grants Awarded 186
3. Disposal of Applications for Research Grants 186
4. Percentage of the Total Value of the Grants Awarded in each Group of Subjects provided for (i) Staff; (ii) Equipment; and (iii) Materials and Services 187
5. Total Values of D.S.I.R. Research Grants Awarded to each University or College, October 1956 to September 1960 188
6. D.S.I.R. Research Grants Authorized between 1st October 1956 and 30th September 1960:
   - (i) Natural Sciences and Technology 191
   - (ii) Human Sciences 225
   - (iii) Space Research 227

Glossary 229

© *Crown copyright* 1962
Extracts from the text may be reproduced provided the source is acknowledged